New reconstructive methods in Scientific Illustration with reference to Systematic Herpetology

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A B S T R A C T

The present work and papers published earlier by the author, together with a detailed introductory chapter, describe the work of scientific illustration at a specialized level and how the development of drawing techniques can contribute to an understanding of the morphology and systematics of snakes.

This work has its roots in the background of the writer as a scientific illustrator. The early phase reflects the disciplines and influence of science, leading to involvement, first with fishes, then reptiles. A later phase arose from contact with the scientific staff of institutions, such as the natural History Museum London leading to an appreciation of, and participation in taxonomy. Illustration+visual recording of data, augmented by field experience, comprised the principal component in the research. Practical considerations directed the study towards snakes from Algeria.

This work has resulted in seven published papers, most in collaboration with established scientists mainly on the herpetology of North Africa. A synopsis of each paper is provided. In some cases the writer's collaborators are from disciplines such as molecular sequencing and computer analysis.

Traditional taxonomic characters are reviewed and new features are suggested to provide alternative approaches and applications. The species under investigation are viewed in the light of current practice in taxonomy and newly published evidence has been considered. Some related aspects are touched on: genetics, for example is not normally a matter for illustration but is of direct concern, as it is a parallel discipline in the investigation of interrelationships of taxa and thus cannot be disregarded.

The illustrative techniques demonstrated here are inseparable from the recording of morphological data. Such recording requires prior perception of what is to be recorded and it is that interpretation which contributes. In processing of material, the experience of graphic recording of observations resulted in the acquisition of a degree of understanding, which was very useful in resolving taxonomic problems, and added an extra dimension.

The contribution that graphic art has made to some problems in taxonomy is discussed. Specimens in a variety of conditions of preservation require a variety of approaches and techniques of illustration. It has been found that artistic input changed from being a purely descriptive record to a means by which, in conjunction with the more standard techniques, novel conclusions could be derived, thus demonstrating an original contribution to taxonomic problems.

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1.0 C O N T E X T S T A T E M E N T

This thesis attempts a bi-disciplinary approach to taxonomy: it began as an unfocused admiration of scaled animals, expressed through graphic art, but later became influenced by science, and is in consequence a hybrid work. The work presented here is in the context of a progression of an overall taxonomic appraisal, mainly of snakes but not exclusively so, incorporating the morphological, climatic and environmental features customarily used in analysis. Spadework on museum specimens was supplemented by field collecting. The visual concept/content was always uppermost in mind: drawings, although used sparingly in the published works in conformity with convention, formed the inspiration and the substance of the investigations. The methods of scale grouping and reconstruction were developed, the former for visually processing large quantities of material, the latter for including specimens in bad states.

The earlier drawings in this work (Figures 1 and 2) are examples of an incipient awareness to taxonomy; Figures 3, 5, 8 and 9 represent those in which the science has already "taken root". The remaining studies were executed purely for taxonomic herpetology and involved varying degrees of reconstruction, or at least some modification, during preparation of which (detail below) revealed previously unrecognized, but demonstrably useful taxonomic characters. The term 'character' used here is any distinctive feature of the morphology of an animal or plant by which it may be recognised and that will contribute to the identification of the species. Character 'state' is the degree of development of a character. Thus, if the character is 'body pattern' the 'state' would be the condition, i.e. spotted, banded or striped as the case may be.

The focus shifted from a broad interest to the false smooth snakes; thence to other species in Algeria. That country, which by virtue of its central position in North Africa and its vastness, made it an ideal place to direct herpetological studies. From the Algerian "base", in collaboration with other authors, the present writer extended the study beyond the borders of the Sahara into tropical Africa.

1.1 BACKGROUND. The study is attributable, from its inception, to "aesthetic" inspiration. The American art collector Arthur Sackler hints at the closeness of art and science "Science is a discipline pursued with passion: Art is a passion pursued with discipline". SIMPSON (1961, p. 140) wrote that "...the personality factor can no more be eliminated from classification [part of taxonomy] than from any other art." For the present writer all these considerations reinforce the idea that art and the science of taxonomy are inextricably linked and the science is advanced by graphic, i.e. illustrative, contributions.
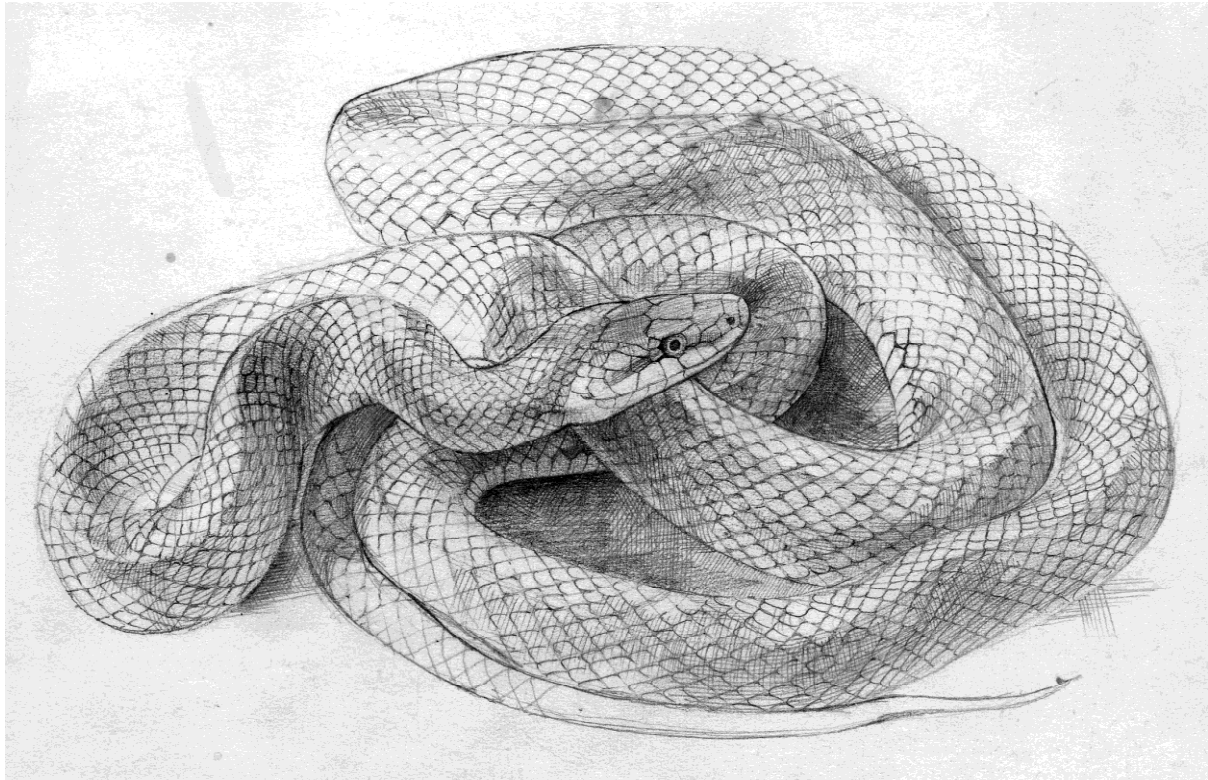
Figure 1. Aesculapian Snake (*Zamenis longissimus*). An early pencil study before the method of grouping of scales had been devised (reduced 87%, ca. 1963) .

The writer's early training consisted of a thorough grounding in art and design in which draughtsmanship and critical observation were always a high priority. These implanted an appreciation of form, space and the representation of light and shade in terms of the media used. Engraving on wood (Figure 2) further concentrated the skills acquired towards precision in execution. Wood engraving had the added advantage of natural affinity with typography. This basic training proved integral to the value of the illustrations produced later, and ultimately to the writer's taxonomic investigations. The transition from the pictorial/graphic phase to the taxonomic can be seen in the illustrations: Figures 1 & 2 are drawings (and the subsequent engraving) executed prior to the present writer's discovery of the scale grouping method (3.2), and in consequence, while giving a general impression, are not strictly accurate. Figures 3 & 5 show the results where initial consideration of the scales in groups, later splitting them into their components, can facilitate accurate portrayal in difficult situations (see 3.3.3).

1.2 INFLUENCE OF SCIENCE Contact with the Division of Fishes and Reptiles at the Natural History Museum, London, initially in the capacity of an illustrator, instilled in the present writer an appreciation of taxonomy. There are a number of cases of contributions to herpetology in which drawing was an integral part; either as the illustrator in collaboration with the author, or as both. JAN & SORDELLI (1866-70) attempted to catalogue and illustrate, with line engravings, all the snake species. F. Sordelli prepared the drawings.
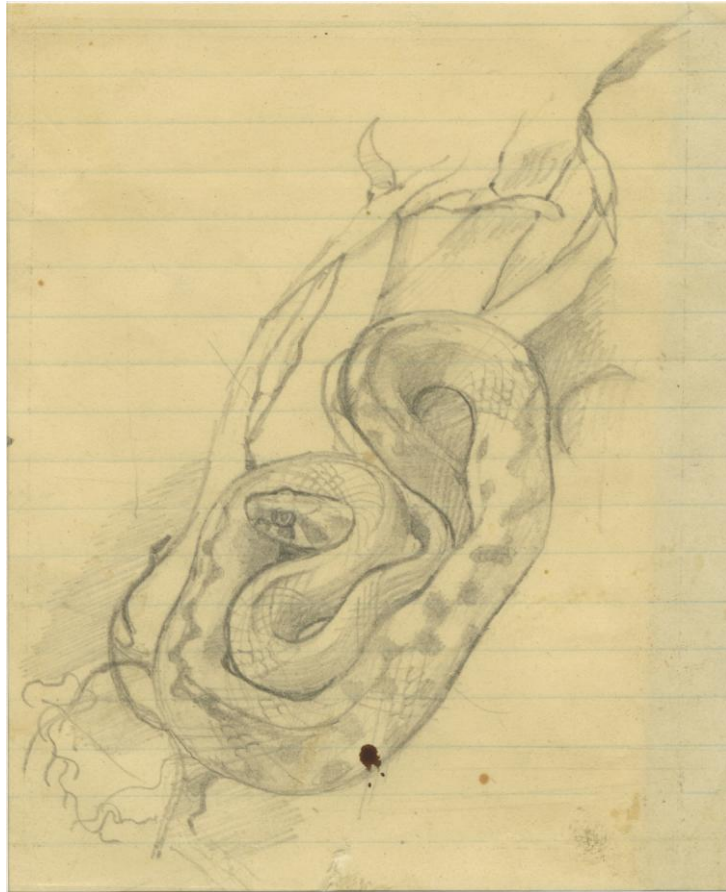
Figure 2. Viperine Watersnake (*Natrix maura*). Pencil study and wood engraving (natural size).
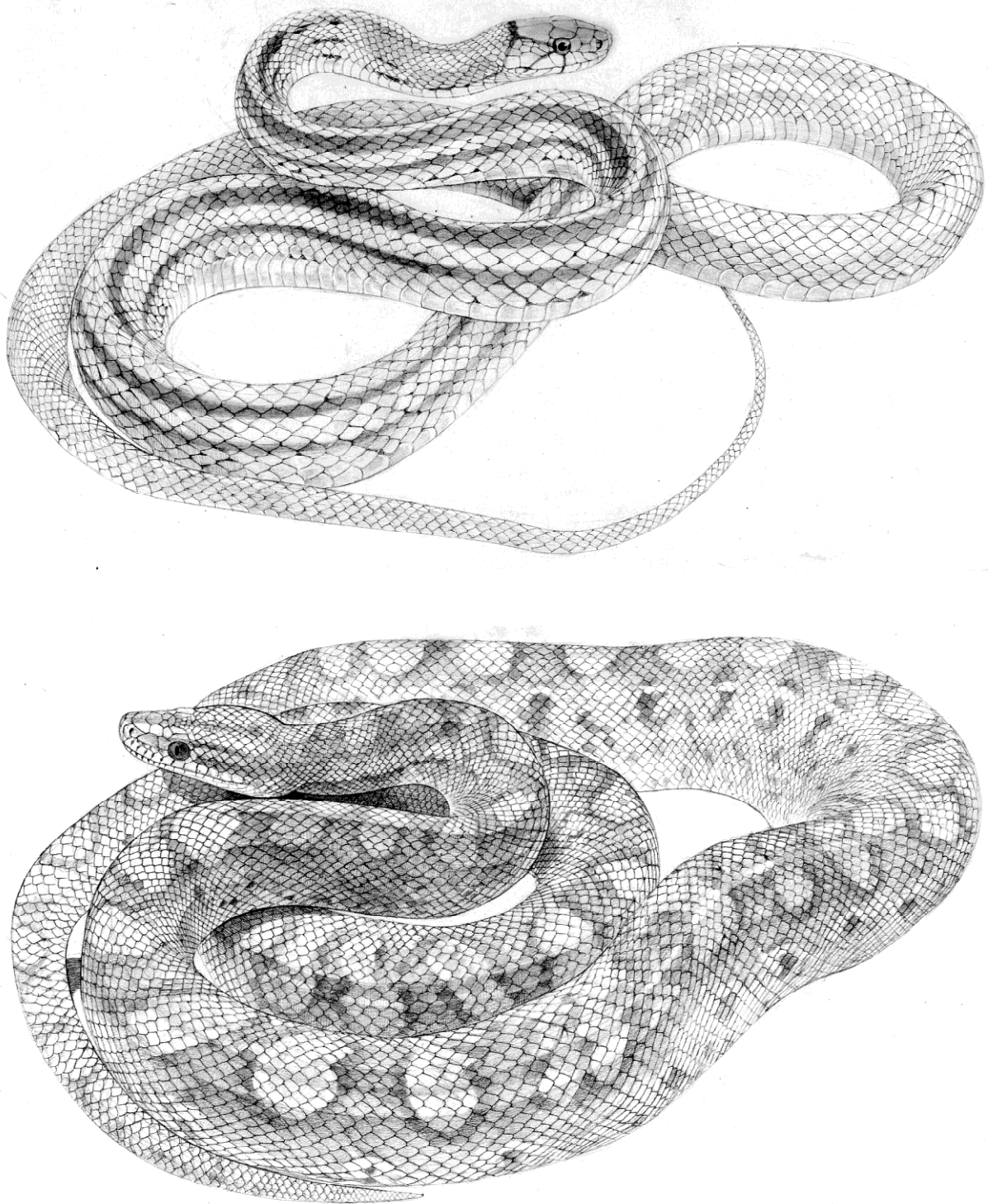
Figure 3. Upper, Asiatic Copperhead (*Coelognathus radiatus*) and lower, Rainbow Boa (*Epicrates cenchria maurus*). Pencil drawing drawings using the scale grouping method, showing the differences in scalation and body forms (reduced 56%).

Particularly impressive were the magnificent late 19th century lithographs of fishes by P. J. Smit and J. Green illustrating the works of A. GÜNTHER (1830-1914) and G. A. BOULENGER (1858-1937), and recognized the importance of scientific accuracy in portrayal. Several examples relevant to this work are to be found in the work on the herpetology of Barbary (Morocco, Algeria and Tunisia), which are

illustrated by lithographs in BOULENGER (1891, Pl. XVIII) the teo newt specimens of "Molgre *hagenmuelleri*" (Figure 4), were part of the series from Annaba examined and renamed *Pleurodeles* illustrated by lithographs in BOULENGER (1891, Pl. XVIII). The two newt specimens of "*Molge poireti* by CARRANZA & WADE (2004). The same plate shows an entire specimen of the Southern Smooth Snake (*Coronella amaliae* [=*C. girondica*]) from Tangiers (Figure 4, 1a) together with subsidiary drawings (Fig. 1, b and c). Fig. 2a, is of a complete specimen of the dune or Avicenna's Viper (*Cerastes vipera*) from Tripoli, showing the divergent condition of the upper dorsal scales noted for populations north of the Sahara, as opposed to the parallel scales in those from the Sahara proper (see Appendix III, Figure 36).

At least three internationally renowned snake taxonomists have started their careers as artists and subsequently "crossed the floor". Edmond V. MALNATE (in litt.), an American who was originally a graphic designer, illustrated his own papers and became one of the two authorities on Natricine snakes, Garth UNDERWOOD being the other. Brian GROOMBRIDGE, originally a fine artist who trained at Hornsey College of Art, specialized in systematics at higher levels of classification - especially with reference to the Viperids.

Perhaps the most controversial, is the American herpetologist, Samuel B. MCDOWELL, who began as an illustrator, was possibly the only person who truly made effective use of drawing as a tool of enquiry as opposed to merely illustrating his work. One of his areas of expertise was the family Elapidae i.e. cobras, coral snakes, sea snakes and their allies; he used his own illustrations in his papers. His controversial paper of 1968 "Affinities of the snakes usually called *Elaps lacteus* and *E. dorsalis*" is significant. It could be seen as an example of vindication of intuition against 'received wisdom' of the day (KOCHVA & WOLLBERG, 1970; UNDERWOOD & KOCHVA, 1993 (see Appendix VIII).

1.2.1   Well-preserved and properly fixed specimens were essential in order to produce successful "free" drawings, i.e. without the use of any mechanical aids. The techniques in use by museums were modified to set the specimens in positions most advantageous for drawing. Methods for accurately recording complicated scalation were developed (see below) of which Figure 3, a, the Copperhead Racer (*Coelognathus radiatus*) and b, of the Rainbow Boa (*Epicrates cenchria*) are early examples. Careful observation of the scales, using the method of scale grouping (3.2), although drawn freehand resulted in successful depiction of form. A specimen, the Hump-Nosed Pit Viper (*Hypnale hypnale*) (BMNH 1984.726) in Figure 5, was similarly treated. The Barbel, Tench, Windermere char and Rainbow Trout (Figures 8, a, b; 9, a and b respectively) are drawings from carefully preserved specimens using proportionate dividers to ensure accuracy.

Among vertebrates fishes are particularly adept, in a short space of time, to modifying their morphology in response to environmental changes. Specimens cultivated in the aquarium, itself an unnatural environment, would manifest features, especially those used by the taxonomist i.e. body proportion, dentition etc., which had arisen due to aquarium conditions. Drawings of such specimens
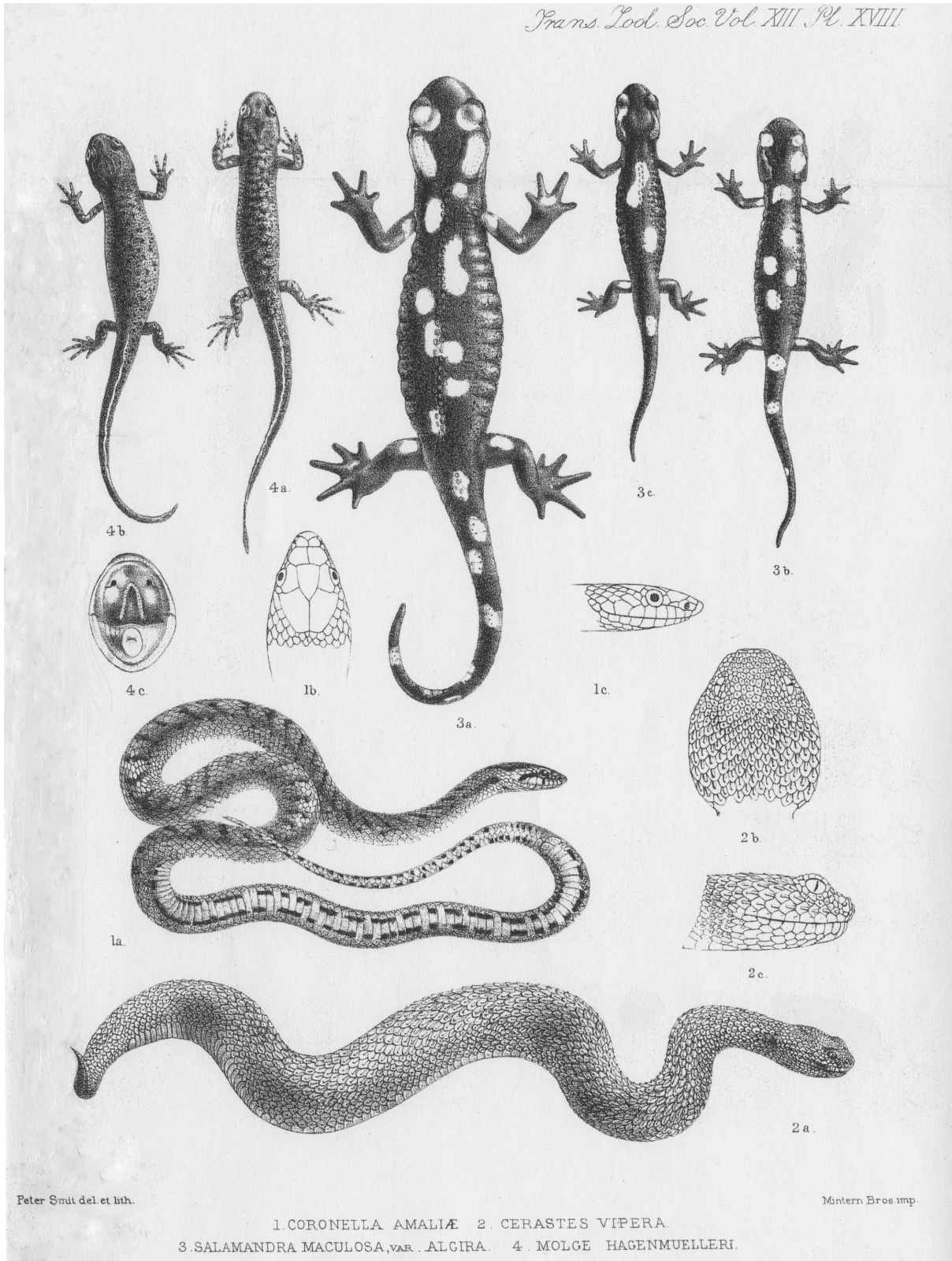
Figure 4. Lithograph from BOULENGER (1891), Catalogue opf the reptiles and batrachians of Barbary, Pl. VIII. Figs. 1, a-c *Coronella amaliae* [=*C. girondica*] from Tangiers; 2, a-c *Cerastes vipera* from Tripoli; 3, a *Salamandra maculosa* var *algira*, adult ♀ from Annaba, b & c, young from Tangiers; 4, *Molge hagenmuelleri* [=*Pleurodeles poireti*] from Annaba, a ♂, b ♀; c mouthparts.
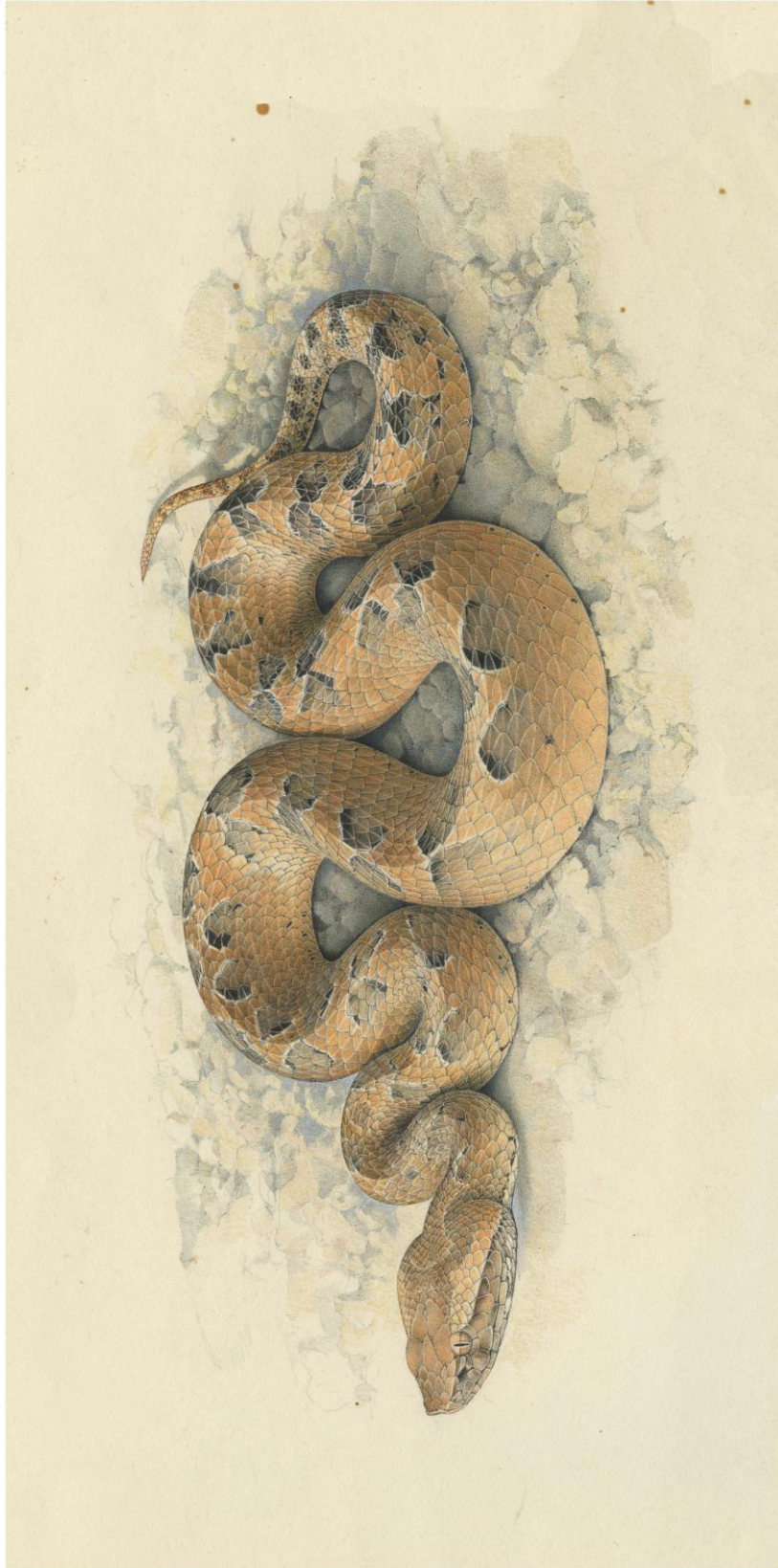
Figure 5. Hump-nosed viper (*Hypnale hypnale*) BMNH 1984.726. Gouache drawing using the scale grouping method (natural size).

"...would be of limited use to science" (P. H. GREENWOOD, personal communication, 1968). This consideration, plus restrictions imposed by limitations of size of aquaria, and in consequence size and variety of the subjects, rendered fishes in captivity unreliable representatives as would exist in the wild.

Reptiles, being less labile in this respect, presented a more realistic option for study. Lizards did not excite quite the same fascination as snakes and would require greater care and attention. Moreover, the majority of them, even the nocturnal forms, required direct sunlight, ultraviolet not being readily available as an alternative light source during that 'exploratory' period of the 1960s.

1.2.2   In summary, acquisition of a rich understanding of the general field of natural history exemplified by long experience in the study of reptiles led to discovery of a unique method for processing scalation and other visible features and the development of a method of reconstruction. The experience resulted in six published papers, two of which the present writer was sole author in which a new species was discovered, and four which he co-authored in which another was described.

2.0 C O N T R I B U T I O N   T O   K N O W L E D G E

The advantages of illustration in relation to other means of conveying information are discussed. The significant contribution of the scale grouping and reconstruction methods is described, its usefulness is explained with reference to specific examples in the publications and the commonality of the method to all aspects of the research which invilve scalation. Conservation and medical aspects are noted as being areas of immediate practical application.

2.1 The contribution to knowledge is of interest to both herpetologists and scientific illustrators and may be summarized as:

- Providing a method of rapid analysis and processing of visual information.

- Obviating or reducing the need for recording extensive text matter.

- Providing immediate access and reference to useful, or potentially useful taxonomic character states (the intimacy much of which would be lost by text or tabulation).

- Having revealed new diagnostic characters.

- Ability to address situations or enter areas/ largely denied to science eg. 'general appearance'.

2.2 The unique method of grouping scales was discovered by the present writer (see below, Gaphic analysis, 3.1) during the course of illustration and comprises the following elements:

- Factors which led to the formation of the method of grouping scales.

- A description of the method itself, i.e. the establishment of hierarchical groups for addressing problems involving large numbers of scales.

- Being a key element in reconstruction of substandard material.

- Applicable to other biological and non biological subjects.

These considerably eased the problems of not only drawing the scales but also restoring damaged or incomplete specimens to their original condition.

This enabled the "topographic" aspects such as scalation, pattern and proportion of large numbers of specimens to be recorded, and presented in identical manner for easy comparison. The publications by WADE (1988 and 2001) are the direct results of applying this process to taxonomic study. Figures 3, 4 and 5 of WADE (2001) show, after reconstruction, the heads of 12 examples of *Macroptotodon* and their variations portrayed in identical manner in a position most advantageous for analysis. The figures 1 and 2 in HUGHES & WADE (2001) by contrast depict only two specimens which, fortunately had been preserved in a similar positions; the second of the two, being emaciated, fequired "filling out". The present writer's contribution in CARRANZA et al. (2004), although not illustrated, was an indirect result of the process, insofar as the morphological content was based on the extensive

illustrations amassed by him during the course of his research for which the reconstructions were an integral part (Appendix I).

2.2.1 A valuable by-product of drawing, especially the grouping method, has been the revelation of new and potentially useful characters, or unrecognized states of characters such as those in midbody scalation in salmonid fishes and snakes (see 3.2.1, Figures 7, b & c; and 29 & 30 respectively). Moreover, the actual drawing of part of a specimen may reveal hidden states which may otherwise be overlooked using the standard means of recording, as exemplified in *Hemorrhois-Spalerosophis* complex Figure 34; *Naja haje* ssp Figure 35; *Cerastes vipera*, Figure 36; *Rhagerhis*, Figures 29 & 30 etc. (Appendix III).

The scale grouping method may equally be applied to any other situation or subject in which regular formations of units, especially where areas of foreshortening are involved. Leaf formations or strobili of various exotic plants (such as cacti, *Aluaudia*, *Araucaria* or Cicads), or non biological subjects such as bricks, tiles or railway sleepers etc. may be dealt with by this method.

2.3 VALUE OF ART TO TAXONOMY. Historically, morphology has been the method used for investigating interrelationships between reptiles, but it was not without problems: BAILEY (1967:155) observed "...the occurrence of parallelism and divergence affecting most of the characters which have been used in classification". Morphological methods were later 'challenged' by those of biochemistry (e.g. immunology, CADLE, 1984 etc.; HERRMAN et al., 1992) until different biochemical methods gave conflicting results. Recently DNA sequencing which, together with the currently fashionable cladistics, are currently considered the best approximation by which relationships are established.

2.3.1 Morphology can be regarded as the most 'stable' of the aspects of systematic or taxonomic investigation, the results of which can be checked or more easily verified visually than by other methods. Art, principally draughtsmanship, provides an added dimension. The drawn figure has so far been the means of depicting, for comparative purposes, preserved specimens in which the characters and their states may be observed without the distractions of conditions of preservation (3.3, Reconstructive Methods). Subtleties and complexities in some morphological features (e.g. variation in scalation and pattern) are more easily described by drawings. The selective capacity of art enables extrapolation of any desired feature to be depicted and presented in the same manner. Characters not easily qualified by customary methods, i.e. the 'nebulous concept of general appearance' lend themselves more readily to recording by 'visual' means. Drawings not only reduce the necessity for extensive descriptive text but also of making mental adjustments. Photography is the means most commonly resorted to for illustration, mainly for economic reasons. Photographs of live animals, while attractive and giving a general impression, rarely depict all the desired detail; those of preserved specimens, unless retouched, portray the condition of preservation with any attendant distortions of

detail.   Drawing addresses problems which photography, with all its advantages, is denied. Moreover, badly preserved or damaged specimens may be reconstituted to original, i.e. 'natural' condition, by drawing+reconstruction. It remains as yet, until challenged by digital/computerized methods, an area into which science is excluded.

There are cases where the specimens have been lost and illustrations provide the only remaining record. Many museum specimens were destroyed by Allied bombing of Milan, Munich, Dresden etc. during the Second World War (Dr M. Podestà, in litt.). Fortunately, in the work of JAN & SORDELLI's "Iconographie générale des Ophidiens" (1860-81), the published plates which depict some of the snakes from the Museum of Milan have survived. They are in sufficient detail and have been of value in the preparation of WADE, 2001 (see Figure 19, 4.3).

2.3.2 Taxonomic drawings have relevance to conservation and medicine as the understanding of species delimitation in those domains is far from complete. KELLY (2005), writing on the Psammophiine snakes with respect to conservation, recognizes *species delimitation* as being of *key importance*. Ideally, species should be able to be recognizable, particularly when encountered in the field. To achieve this would involve understanding of the morphological inter-and intraspecific variations, and, especially in the case of the Montpellier snakes, the ontogenetic changes also (see Genus *Malpolon*, Appendix II). Graphic Analysis (3.1) in support of the morphological and molecular methods of investigation, would present a more comprehensive picture of the diversity of taxa. Given the decline in numbers in recent years the need for such multidisciplinary investigations becomes increasingly desirable.

Species recognition is also important for medical reasons. Bites from two possible species of Saw-scaled viper, *Echis pyramidum* and *E. leucogaster*, could be problematic in western North Africa as no reliable method has been established by which they can be differentiated and consequently their distributional limits are not known for certain. A further complication lies in that the antiserum for the bite of one species may have little effect against the bite of the other, as exemplified in a case involving a captive specimen (GILLISEN et al., 1994; also see Genus *Echis*, Appendix II). The problem exists, not only in the field, but in vivaria also, as the provenance of specimens available from commercial dealers is often not supplied. These considerations, together with their irascibility and high toxicity of the venom, renders them particularly dangerous. Thus for the Saw-scaled vipers detailed drawings presented in identical manner, from the medical point of view, would be desirable.

3.0 M E T H O D O L O G Y

This section deals with a systematic method for observing and recording the visible features of certain fishes and snakes. The main features of the method of scale grouping is described in detail. Reconstruction methods were developed and refined through scientific illustration. The wider context of the works are briefly discussed. From a variety of morphological characters which lend themselves to illustration discussed in Appendix III: Characters Useful in Snake Taxonomy, those of scalation formed the primary focus for the systematic method of analysis devised and described in this section

3.1 G RAPHIC A NALYSIS

A systematic method of analysis was devised and is described below. It formed the foundation for the methods used in the research. While scientific accuracy was the primary objective, care was exercised in order that the appearance of the specimen be made as lifelike as possible. Dealing accurately with scalation was initially daunting but the problem was resolved by arranging scales into groups which would be divided and repeated as necessary depending on the numbers of scales involved.
Some form of reconstruction is usually necessary when a drawing in identical position to others, is undertaken, and may involve a series of steps before an image is produced. Reconstructions beginning as 'tidying up" of specimens during illustration were increasingly refined *pari passu* with experience. The method truly came into its own when damaged specimens were addressed (see below, 3.3 Reconstructive Methods). The method was found to be successful on mutilated specimens, such as roadkills, which constituted a significant and integral portion of material examined in snakes of the genus *Malpolon* and *Rhagerhis* (see Appendix II, Work in Progress).

3.2 SCALE GROUPING. The convenient abbreviations and terminology devised by BREDER (1972) for scale rows of fishes have been applied also to those of snakes. The *L* series, on the lateral line in fishes, applies in this work to any longitudinal row in snakes; *C*="clockwise" refers to the forward (on the left side of the specimen) direction of the diagonal row \; *R*=anticlockwise, "retrograde" refers to the backwardly directed rows **/** (Figures 6 & 7). The *T*=transverse arrangement refers to the vertical alignment of the posterior margins of scales (Figure 11). This character applies principally to drawing snakes, and is particularly valuable in reconstructions (see below 3.3).

The method was arrived at in a number of ways. The main quality of wood engraving is the simplicity of line: "fuzzy", or ill defined marks from half tone media, such as a pencil, would not be possible. Having executed wood engravings of snakes from preliminary studies, and inspired by the precision of the craft, accurate observation of the scales in order to depict form became a priority. In a drawing of a snake stripped of tone back-up, any malobservation of the scales, would disrupt the "poetry" of the body scalation. While such inaccuracies may have been implicitly acceptable in illustrations, even

in the lithographs of the late 19th century (see Figure 4, 2a), depicting the "poetry" (for want of a more precise term) of scalation now could no longer be resisted.

3.2.1   Early studies were made from specimens, mainly donated by dealers, incorporating modified fixing and preservation techniques. During the course of any freehand, eg. life drawing, mental notes are made on positions of reference for its 'build up'. In the case of drawing whole snakes, accuracy was essential, as misplacing a scale meant the misplacement of a row of scales, which resulted in loss of form. For convenience, not less motivated by increasingly poor eyesight, the specimens were marked by white gouache paint at strategic points.

Addressing the problem of drawing fine-scaled fishes such as the tench and salmonids (Figures 8 and 9) necessitated the devising of a way of dealing with such large numbers of scales as groups which could be broken down into smaller units, the "strategic" points highlighted, and measurements taken using proportionate dividers and thence transferred to paper. The impetus for formulation of the method in its refined state, with its divisions at regular intervals as presented below 3.2.2, Figure 6, was occasioned by the need to address foreshortening in the coils of the many-scaled Rainbow Boa (Figure 3, b) against which proportionate dividers were of no use. The specimen, "marked up", was then drawn freehand.

The influence of less obvious factors subconsciously played their part. The combination of awareness of regularity in the arrangement of bricks, tiles, railway sleepers etc. was noted, subconsciously "earmarked" for future use during the present writer's period of architectural drawing, and serendipity doubtless were involved.

3.2.2   Numerous scales, however small, if more or less regularly disposed, could be drawn provided they were divided into smaller groups in which each group may be divided and subdivided successively in the middle. Figure 6 shows the method; a, schematically, as a lattice of 60°; and **b**, as applied to a fish with a moderately high number of scales (in this case the Barbel). A series of 64 scales along a horizontal (*L*), considered as groups of rhombs, could be divided in four stages by successively halving each group. Thus at the first division the numbers of the points of reference at the end of the first series are 33 (i.e. $n=8$ rhombs) + 32 ($n=8$ rhombs commencing on the 34th point and terminating at the 65th) in the second. Similarly the second stage/division would be made at reference point no. 17, thus grouping 17 points ($n=16$ rhombs) and 16 ($n=16$ rhombs). Thus by successive bisection at each midway point along the series, the 4 remaining stages finish with the last division as a single unit or rhomb into which a scale would be drawn.
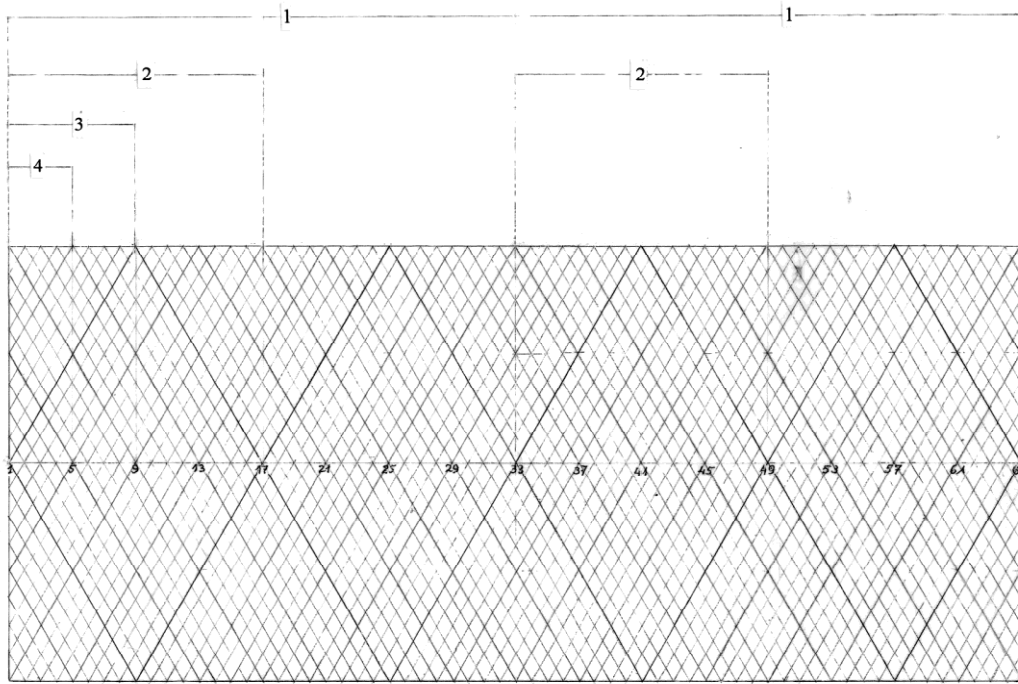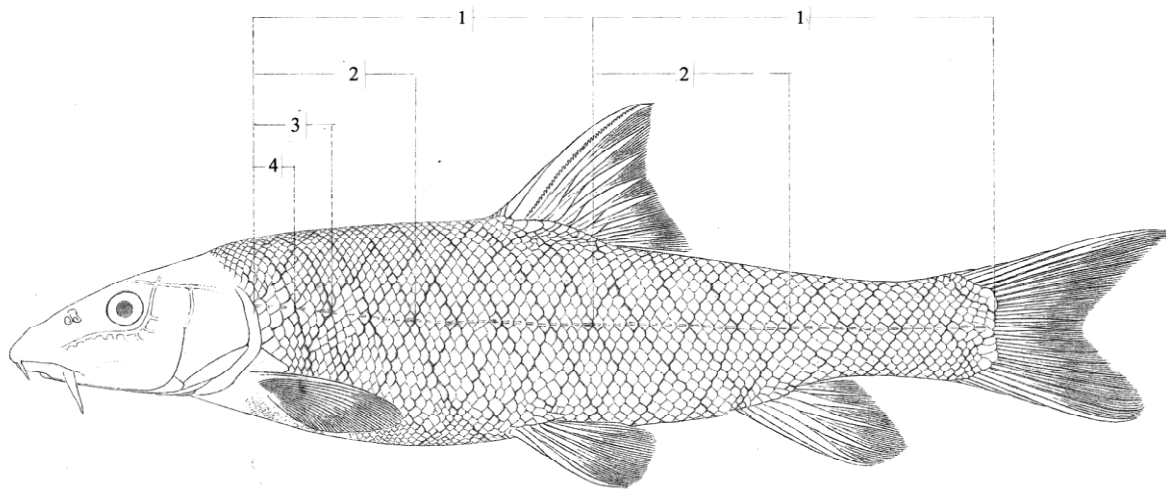
Figure. 6. (**a**) Lattice of 60° incorporating a longitudinal series of 64 rhombs/diamonds. Grouping of individual rhombs in which the stages are numbered (see text for details). (**b**) The method (above) adapted to the Barbel (*Barbus barbus*) to which it approximates in the numbers of scales in the longitudinal series and their inclination. The ranges of the degrees of inclination, sizes+foreshortening of the scales are enhanced: the irregular rhomboids (containing sometimes less or more than 16 scales) are due to the shape under the influence of anatomy and locomotion.

A linear progression of 65 reference points incorporating 64 units in groups of 4 would be expressed as: 1: 5: 9:13: 17: 21: 25: 29: 33: 37: 41: 45: 49: 53: 57: 61: 65. With the other rows (the *C* and *R* diagonals), not only whole groups of scales can be assessed, but changes of axes and foreshortening can be determined. This generally makes for the successful rendering of form. The procedure involves

establishing reference points from or against which the scales may be grouped, either from a transposition or actual marking on the specimen. Reference points were established on all specimens drawn using this method. It worked most easily in subjects where the scales were disposed in a regular formation, its usefulness diminishing as the regularity of the scale arrangements decreased. In some reptiles, e.g. chameleons, the procedure would be inapplicable. Figures. 3 and 5 depict the results where this procedure has been applied, the snakes drawn freehand, and Figures. 8 and 9, depict the fishes which were the result of measured drawings.

Tench   **Rainbow Trout**   **Windermere Char**
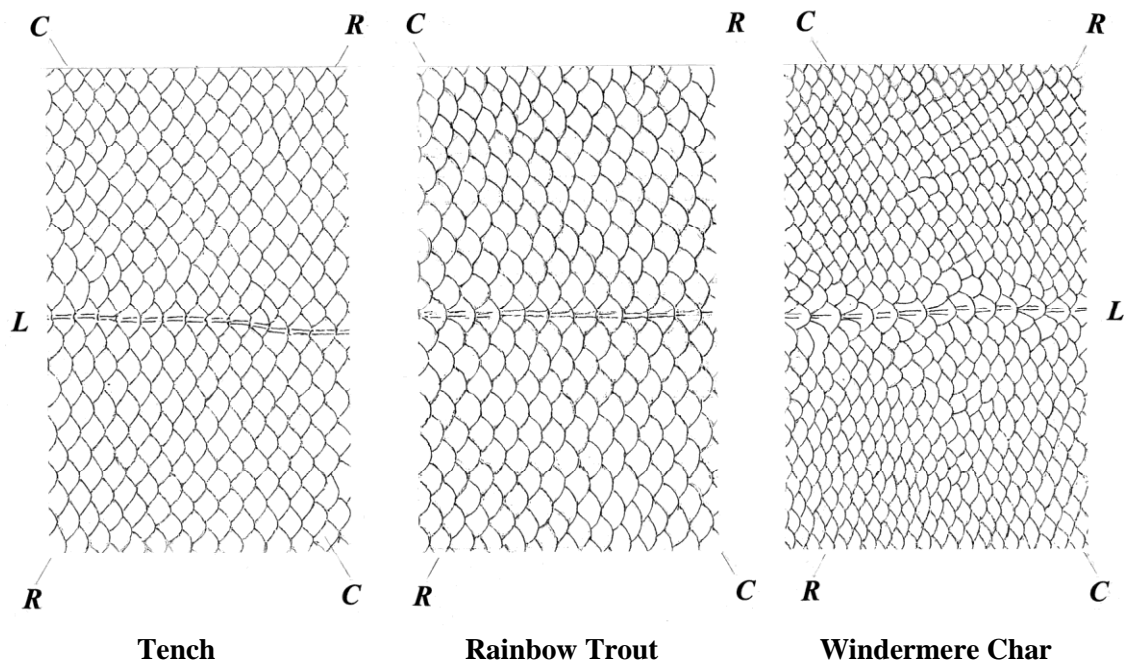
Figure 7. Flank scales in relation to the lateral line in approximate alignment with the origin of the dorsal fin in a Tench, a Rainbow Trout and a Windermere Char. In the trout and char the **C** rows of scales are more regular *above* the lateral line and irregular *below* it. The reverse is manifest in the **R** rows in which irregularity occurs above the lateral line and irregularity below it. These conditions become more pronounced towards the margins of the specimen (see Figs 8 and 9). No such recognizable states are manifest in the Tench.

3.2.3.   An early example of hitherto unrealized character states which became manifest during the course of drawing is shown in the enlargements of a part of the fishes in Figure 7. The two salmonids, the rainbow trout and the Windermere char are shown: a fine-scaled cyprinid (a tench) is included for comparison. The trout and the char exhibit an unusual condition in the arrangement of the scales. The diagonal rows **C** are more or less regularly disposed *above* the lateral line: *below* it the scales become irregular, erratic and/or dividing towards the margins of the fish. The reverse is the case for those represented by the diagonal rows **R**, those above the lateral line being irregularly, and those below it, regularly disposed. The irregularities are more pronounced in the char and may have taxonomic value in salmonids but a more full import may be realized later. Whilst irregularities, which have inhibited counting above the lateral line, have been noted by various authors, the present writer is unaware of any reference to the condition described above: surprisingly, neither NEAVE (1943), nor BREDER (1947; 1972) made any mention of this feature.
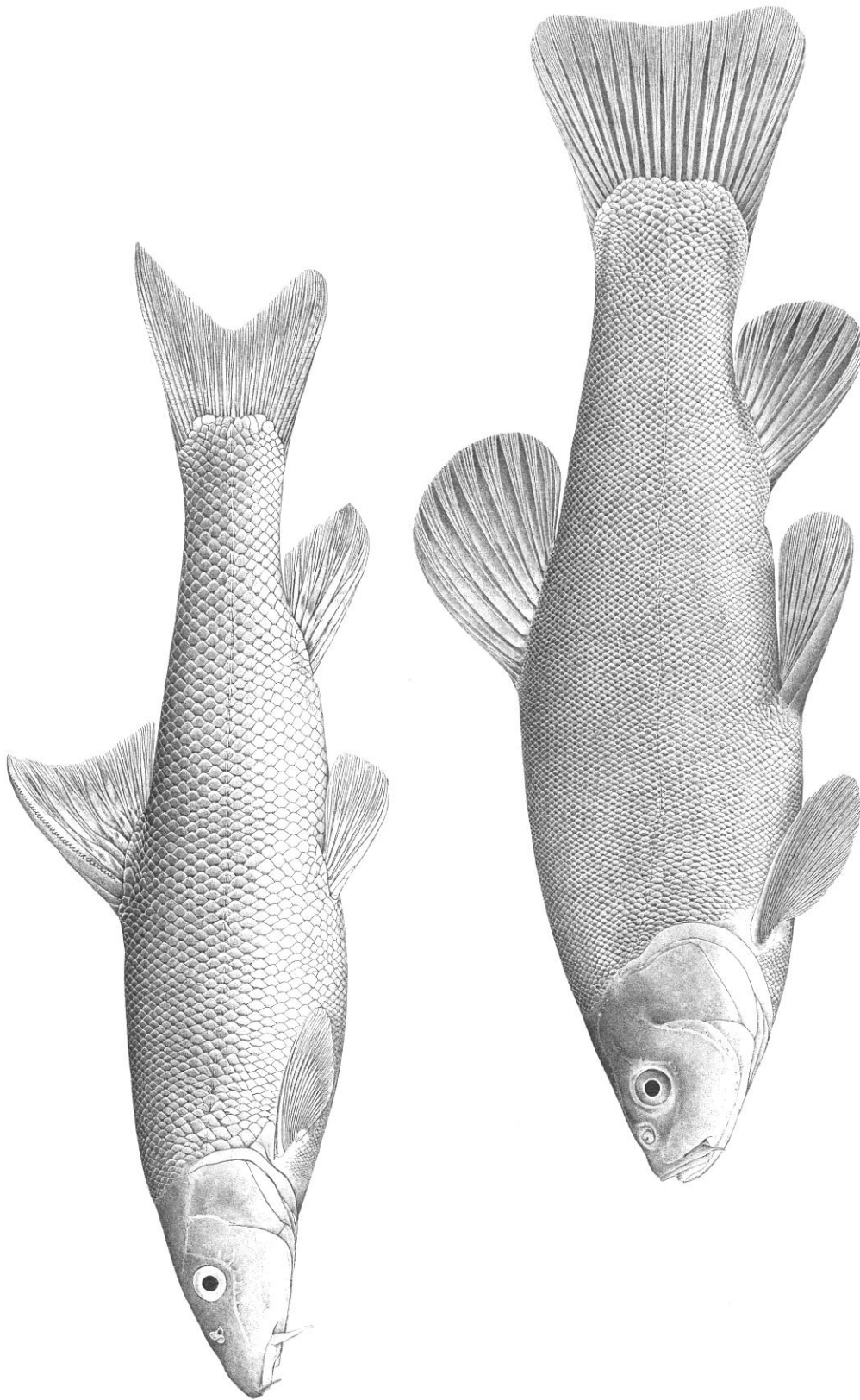
Figure 8. (Upper) European Barbel (Barbus barbus); (lower) the Tench (Tinca tinca). Pencil drawings from preserved specimens applying the scale grouping method in combination with proportionate dividers.

Figure 9. (Upper) Lake Windermere Char (*Salvelinus alpinus*); (lower) the Rainbow Trout (*Salvelinus mykiss*). Drawings in gouache from preserved specimens applying the scale grouping method in combination with proportionate dividers

3.2.4   Where snakes are concerned, most of the scale characters useful to the taxonomist occur on the head. This is customarily portrayed from dorsal, lateral and ventral aspects. Most of such drawings in scientific papers reflect the rigours of death. This would be acceptable if the manner and position at death were the same in all those that are illustrated but such is never the case. The fine Victorian lithographers, P. J. Smit, J. Green illustrated the works of BOULENGER, GÜNTHER and others depicted whole specimens in lifelike positions (with varying degrees of success): but the labour involved would explain why such work is seldom seen nowadays.

Preliminary studies were made using a stereoscopic microscope with a camera lucida attachment. The studies were reduced (or enlarged) to a convenient size; i.e. one that fell comfortably within the ambit of the use of proportional dividers, with the further consideration that the drawings produced would later reduce without loss of quality.

As the vast majority of specimens were fixed in unnatural, contorted positions, the drawings of each were to be as when straightened out and seen in dorsal, lateral and ventral aspects, standardized to the same size for easy comparison. The scales were then mapped out in pencil on tracing paper, each reference point recorded using the proportional dividers. Using reference points, as created in the grouping method, scales were arranged with regard to their alignment and orientation with reference to the vertebral series and corresponding ventral plate. Any asymmetry between a reference point and its counterpart would easily be recognized, and the scale responsible, as a result of merging or splitting of series, duly noted (3.3, Reconstructive Methods; Figure 15, a-c). Modified callipers (Figure 37 b, Appendix III) were used to measure reference points where the surface was uneven, eg. the snout, eye or temporal scale, as the differences in depths rendered the proportional dividers unreliable.

3.2.5   The other external character important in the taxonomy of snakes in which the grouping method is of use, is the body scalation and pattern. The method provides a framework within which irregularities may occur, and can be contained. KESSLER (1996) describes an excellent method for depicting scalation of 'generalized' snake scale conditions diagramatically or semidiagramatically. He did not address variation in the sizes of the scales, nor the angle of stacking.

Where no irregularities occur, recording is a fairly straightforward matter (Figure 34, a), but for those in which they do occur (see below, Appendix III, Characters Useful in Snake Taxonomy, Body scales), establishing where the vertebral series lie is an advisable first step. The vertebral scales are then grouped and a link is made to an appropriate ventral plate. The connection of the corresponding diagonal rows to the requisite ventral would follow (Figure 34, b-d) and subsequently the points of the irregularities (i.e. scales at which fusions or splittings of series occur) be correctly positioned. Problems of portraying oblique scales (*Naja*, Figure 35) or those of unequal size and disposition

(*Cerastes*, Figure 36, a, and *Echis*, Figure 32) can be helped by this method, although the groups may be unequal or staggered. In snakes in which the scales are so divergent as to manifest no clear vertebral row, as in some forms of *Cerastes vipera* (Figure 36, b), there is no alternative except to follow the oblique rows from each ventral backwards (i.e. along the *R* diagonals) to the points where they meet mid dorsally.

A "template" may be made from a sloughed skin, but it has to be modified to correct distortions in the arrangements of scales due to distension of the interstitial skin, an irreversible result of shedding. In the illustrations of the midbody scalation (see WADE, 1988, p. 241, Fig. 4) the distortion was acceptable, although some correction was made as much of the pattern was manifest only when the body was bent: the black bars at the scale pockets would otherwise be obscured due to imbrication. The illustrations of the museum specimens with irregular scalation (WADE, 2001, p. 98, Fig, 6, d. & e.) were initially based on the template from sloughs, but were modified using the procedure described above (also see below, Figure 11).

3.3   R E C O N S T R U C T I V E   M E T H O D S

A procedure for reconstructing human faces from skulls has been developed in the 19th century in Europe, and later in the United States for archaelogical and forensic purposes. It has been refined in the United Kingdom and has been well documented (NEAVE, 1975; PRAG & NEAVE, 1997). It involves establishing points of reference on the skull (or a cast) and a methodical building up of the muscles and soft tissue, layer upon layer of soft clay, to a level predetermined ultrasonically. Variables such as prominence of muscle insertions (indicating bulk) are taken into account. An indication of the general shape of the nose can be determined where the angle of the terminal tilt of the nasal bone when produced meets the distal projection of the nasal spine. The procedures, now highly refined, give consistent results. Experience, and the use of computer technology, has resulted in a high degree of precision, even to the extent of reconstructing from incomplete and even damaged skulls.

3.3.1   However, the procedure outlined above is not applicable to reconstruction of the heads of snakes. The bones which articulate with the skull proper (such as the prefrontals, supratemporals, quadrates, see Figure 22) and those which constitute the 'palato-maxillary arch' are movable, and therefore may alter the shape of the head. Moreover, the premaxilla and in particular the nasals are imbedded in a certain amount of cartilage which is subject to shrinkage as a result of desiccation. In contrast to the human, with its solid skull, there is very little firm base upon which to reconstruct a snake's head and neck, the movable determining its shape. Reliance is, in consequence, based on the

scalation. As with reconstruction of the human head, reference and access to living material is highly desirable.

Whilst reconstructing human heads fulfils archaelogical and forensic requirements, those of snakes are needed mainly for descriptive and comparative, i.e. taxonomic, purposes.

3.3.2   According to SCHMIDT & DAVIS (1941: xii) snakes are "notoriously difficult to draw". The difficulties are often exacerbated by the methods of preservation of specimens. The illustrations in GASPERETTI (1988), "The snakes of Arabia" are examples of the usual condition of the material; the heads of the specimens illustrated had been drawn much as the illustrators found them. The present writer's reconstructions began as 'tidying up" of specimens during illustration, and were increasingly refined *pari passu* with experience of drawing specimens. The method truly came into its own when portrayal of damaged specimens of two viper species, *Pseudocerastes persicus* and a horned individual of *Cerastes cerastes gasperettii*, represented by a shrunk and a damaged specimen, was required. In the interests of scientific integrity, the unsatisfactory specimens were selected in preference to those in better condition as they, unlike the others, originated in the Arabian peninsula (GASPERETTI, 1988; Figs. 113 and 126). They were early examples of reconstructions by the present writer. The method was found to be successful on mutilated specimens, such as roadkills, which constituted a significant [integral] portion of material examined in *Malpolon* and *Rhagerhis*, see Appendix II: Work in Progress.

3.3.3   Snakes of the genus *Macroprotodon*, hitherto the main subject of the research, were so variable in their characters (particularly of pattern) that data on characters customarily used by taxonomists were inadequate in resolving taxonomic problems: the numerous nuances and possible (but as yet unnoticed) states would be overlooked. Recording the *visual*, together with "standard" data was carried out. Photographs, while acceptable for specimens in reasonable condition, were of little value for those that were not. Drawings were made of the heads and necks of all the specimens from poorly sampled areas (see below), from significant geographic regions (eg. type localities; areas of sympatry etc.) and those which showed significant variation. It was desired that the specimens were to be depicted in as near identical manner as possible to reduce the amount of mental adjustment when the resultant drawings are compared with each other. Preserved snakes are virtually never in completely suitable positions for drawing. The heads are nearly always inclined in one direction or other resulting in over-imbrication on one side and corresponding stretching on the other. The main problems in the reconstruction of specimens were: (1) the elasticity of the skin and (2) the distortion of the scales due to 'curling' and shrinkage, especially after loss of the stratum corneum (the horny exterior of a scale).
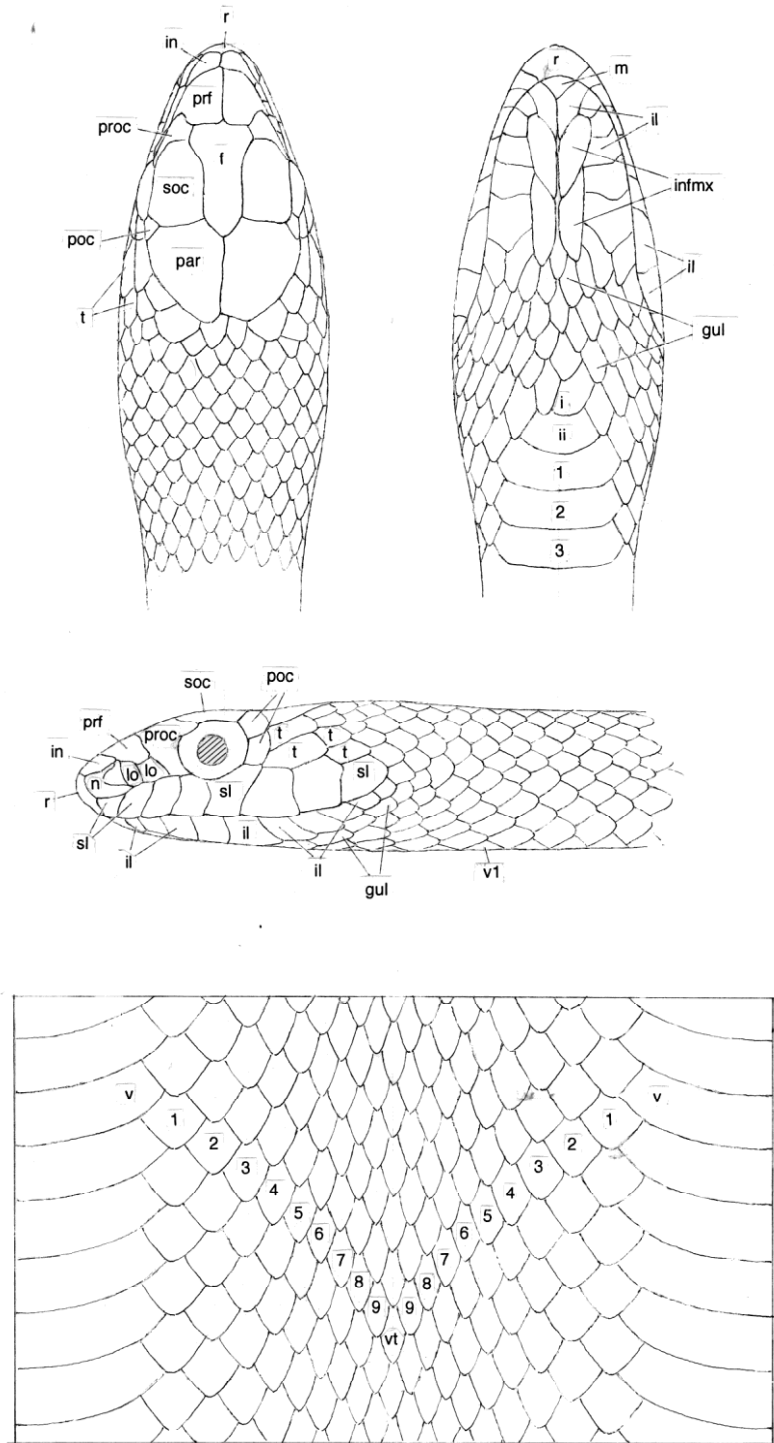
Figure 10. Topography of the Montpellier snake (*Malpolon monspessulanus*). (**a**) Nomenclature of the head scutellation. (**b**) Scales at mid body showing the numbering and the recommended method of counting (along the **R** series). **f**-frontal, **gul**-gulars, **il**-infralabials, **infmx**-inframaxillaries, **in**-internasals, **lo**-loreals, **m**-mental, **n**-nasal, **par**-parietal, **prf**-prefrontal, **preoc**-preocular, **poc**-postocular, **r**-rostral, **sl**-supralabials, **soc**, supraocular, **t**-temporals, **v**-ventrals (Arabic numerals); plates indicated in lower case Roman numerals=preventrals.

3.3.4   Certain features in scalation provide useful guidelines in reconstructions. There is often

consistency in the relative positions of some of the shields, In *Macroprotodon* for example, the rear

margins of the parietals are in more or less vertical alignment with the posterior margin of the last (usually the 8th) supralabial; and the retroarticular process is similarly aligned with the 1st ventral scute. In *Malpolon*, by contrast, the parietals are shorter than the frontal and terminate well short of the last supralabial: the position of the 1st ventral is variable and is often situated in advance of the retroarticular process. Whilst there may be substantial intrafamilial or intrageneric variation in the body scalation with regard to orientation of the *T* axes and counts in colubrids, the scales in *Macroprotodon* on the neck tend, at least posteriorly, to be regularly disposed and usually do not present additional problems.
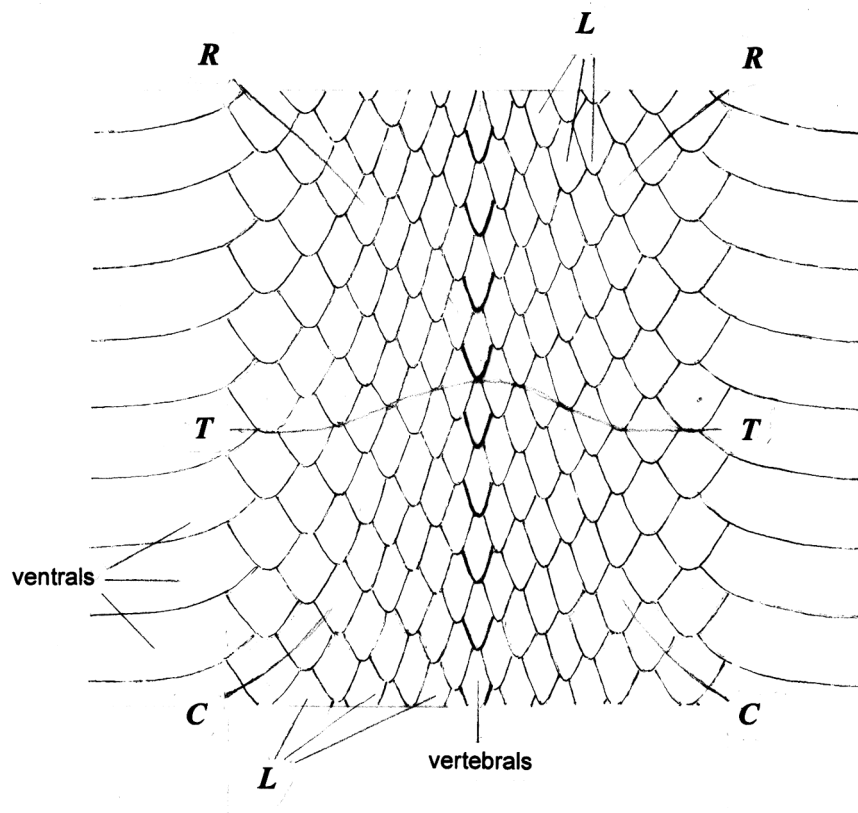
Figure 11. Midbody scalation and terminology of the scale rows in a snake (*Psammophis*). Terminology modified from BREDER (1972). *L*, longitudinal series; *C*, upper left-lower right diagonal (clockwise); *R*, upper right-lower left diagonal (counter clockwise=retrograde), the *C* and *R* series reverse whe the vertebral line is crossed, becoming the *R* and *C* respectively; *T*, transverse series of the tips of the dorsal scales (note the variation in the angles of slope between the dorsal and lower flank scales). The *C* and *R* diagonals refer to direction of the rows and not to the geodesics.

3.3.5   Scales, although variable in their arrangements, conform to (as yet undefined) laws of geometry. Irrespective of changes in counts, places at which fusion or splitting of the rows may occur, the *C* and *R* diagonals and *T* axes in relation to the requisite ventral plates together with the *L* lines, would match up. There is some limited flexibility in interpretation/extrapolation here, as the capability for rectilinear movement of the snake allows for limited shift of alignment of the *T* axes of the scales. This can be most easily observed on a living snake, particularly when held in the hand for close scrutiny: indeed, having immediate access to live material greatly facilitated rendition. At about the

3rd or 4th ventral the scales become pretty well stacked as they would be along the body, that is vertically the axis of each scale tip (the **T** axis, sensu BREDER 1972) may slant slightly forward, but on those nearest to the ventrals (in rows 1 & 3) the axis tilts backwards. The degree of variation depends largely on the position of the reduction in the scale rows. Consideration of scale row reduction formulae (particularly for damaged specimens, see below, 3.4) proved helpful in reconstructions.

3.3.6   On the assumption that it is the *species as represented* by the specimen as opposed to the *specimen itself*, i.e. the condition in which it had been preserved, is required for comparative purposes some form of reconstruction is advisable. The resulting illustrations would be free of such detractions as the variation in the conditions of preservation of the specimens and the dissimilarities in the styles of drawing thus diminishing the need for making mental adjustments (also see below: Appendix II, Characters Useful in Snake Taxonomy: Dorsal scales).

3.4   PROCEDURE FOR RECONSTRUCTING DAMAGED SPECIMENS. GANS, (1959:22) deplored the "all too often indifferently preserved specimens". These almost invariably have been preserved in the field for which perfunctory or no attention has been given with regard to problems that an illustrator may encounter.
Taxonomists or collectors in the field, after having taken the readily accessible details and/or tissue samples, would usually discard a mutilated specimen such as a road casualty or one that has been wantonly killed as further labour would be not be considered "worth the trouble". There may be good reasons for the extra work. The specimen may be a representative of a population poorly known or coming from a critical area material of which is not well represented by collections in institutions. It would similarly be desirable to present a morphological profile (both meristic and graphic) as a voucher specimen from which DNA had been taken (see below Appendix II, Work in Progress, Genus *Malpolon*). Furthermore, specimens accessible in one area may be difficult to find by the same means in another. The present writer was able to locate specimens of *Malpolon monspessulanus* under rocks in Northwestern Algeria, but, in similar terrain in the region of M'Sila surface cover was eschewed (presumably, rodent burrows were preferred): road kills provided the only source of material.

Two examples involving *Macroprotodon*, where such reconstruction was performed, one a desiccated, the other a mutilated specimen, are described in detail below.

3.4.1   DESICCATED SPECIMENS. Five specimens collected from Ksar Chellala (N. Algeria), although in bad condition, afforded a rare opportunity for recording the variation in head pattern and scutellation. They were the first collected from an area from which at that time, so far as the present
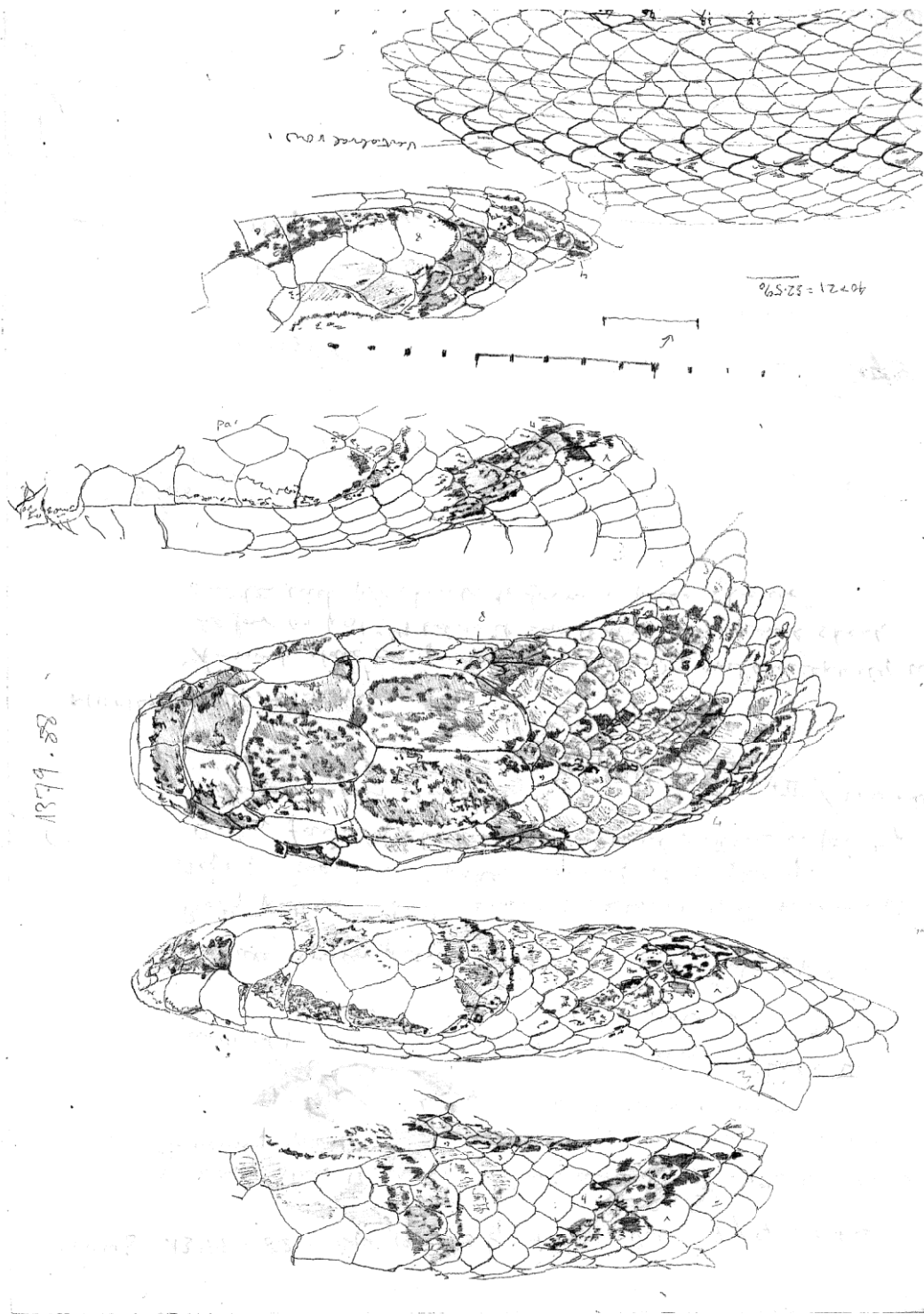
Figure 12. Head of *Macroprotodon abubakeri* (MHNG 1379.88) from Ksar Chellala, Algeria. Preliminary study made with the aid of a 'camera lucida'. The specimen had been formol-fixed and much desiccated (see Figure 13, e for reconstruction).
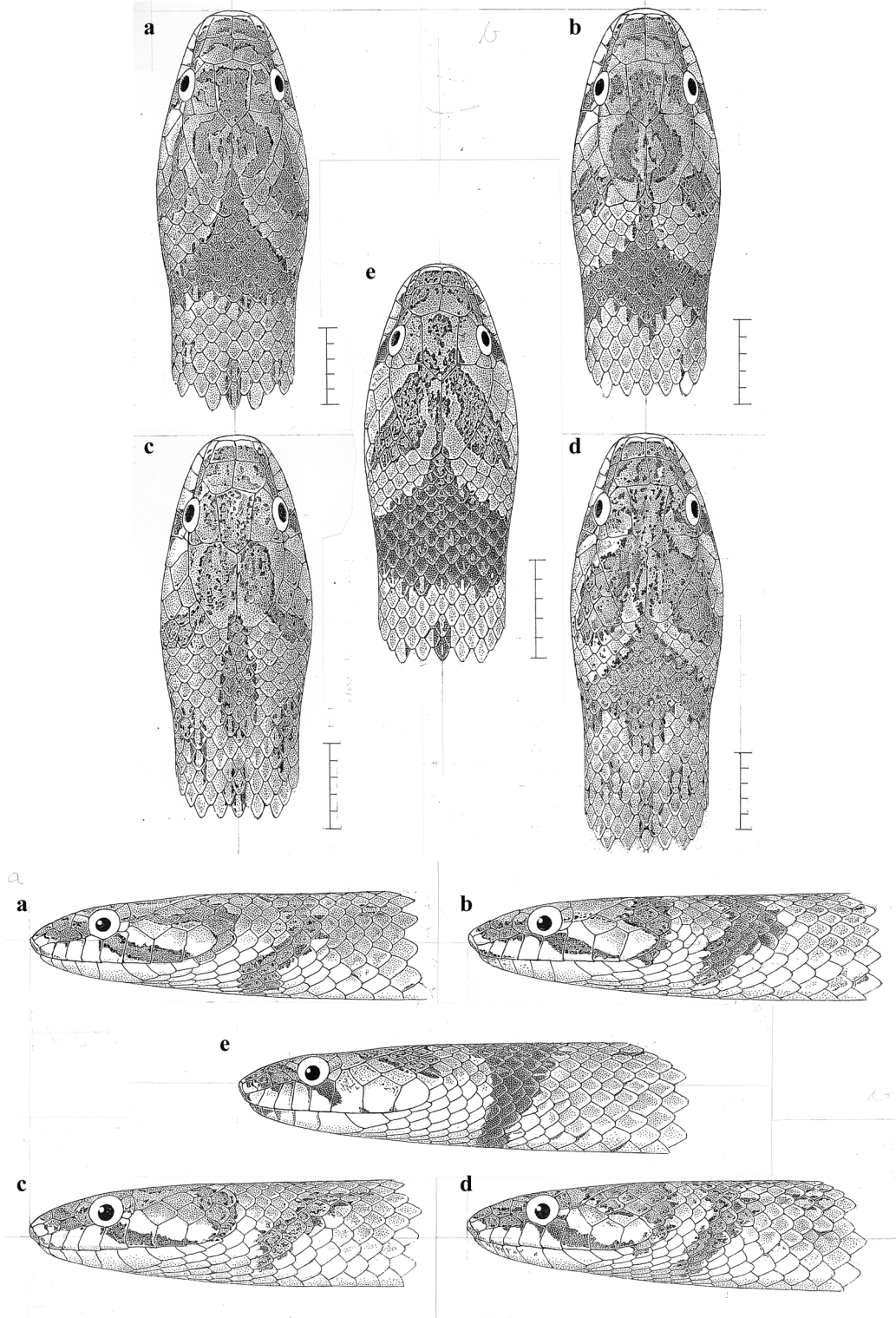
Figure 13. Heads of *Macroprotodon* spp. showing variation in the pattern and scutellation in a sample from Ksar Chellala. (**a**) *Macroprotodon abubakeri* MHNG 1379.85; (**b**) MHNG 1379.86; (**c**) MHNG 1379.88; (**d**) MHNG 1379.89; (**e**) *M. brevis ibericus* MHNG 1214.40 (a Moroccan species: error of attribution or accidental introduction?). Reconstructed from desiccated specimens (scale in millimetres).

writer was aware, no others existed. Ksar Chellala lies immediately to the west of the upper reaches of the Oued Chélif, the Oued Touil, close to and outside the xerothermomediterranean "band", which separates the Mediterranean from the Arid-Saharan regions. In the former region, Ksar Chellala (x=120, i.e. 120 physiologically dry days in the dry season, EMBERGER et al., 1962) included, one would expect *M. abubakeri* to occur, whereas in the latter would be within the range of *M. cucullatus*, as evidenced by a specimen from the not distant Guelt-es Stel (x=190). The specimens from this region merit greater consideration as it approximates the area of abutment between the two species in relation to the bioclimatic divide (see map, Figure 24). The series could not, from the customary method of examination, be easily assigned either to *M. cucullatus* or *M. abubakeri*, the latter being the most likely species to inhabit the region.

3.4.2   The specimens were in very shrunk state. Moreover they had been formol-fixed, rigid and darkened with the pattern considerably obscured. With one exception there were no breakages or tears, the scales (albeit buckled and shrunk) were in contact with each other; the exception specimen was broken at the neck after fixation. The condition of the specimens rendered proportional dividers of little use. Not having access to live material of either *M. cucullatus* or *M. abubakeri*, reliance was placed on experience mainly with *M. brevis* and *M. mauritanicus* in restoring the specimens to their natural condition. The length of the specimen gives some indication as to head proportions. One of the more stable of the head shields, such as the frontal (i.e. least subject to buckling due to shrinkage, especially if intact, i.e. retaining its stratum corneum), was the starting point around which the dimensions of the others were estimated. Other specimens were used for comparison. Considering the head shields in conjunction with the size of the ventral plates, single or in groups, a kind of template was devised, into which groups of scales were placed using the method of grouping (Figure 6). "Key" scales, i.e. those at or from which, rows fused or split, their positions relative to the dorsal and ventrals were noted.

3.4.3   A difficulty, frequently found in badly preserved material, lay in the discolouration of the scales which were not always readily identifiable with regard to their true positions; imbrications were disrupted, resulting in unnatural folding of the skin interrupting the continuity of the rows. The method of reconstruction described above, nevertheless, worked equally well for these specimens, as there were no torn areas which would have resulted in distension of the interstitial skin as was manifest in the specimen dealt with below (3.5). The scales were then mapped out on tracing paper. Figure 12 shows the preliminary study of the head of *M. abubakeri* (MHNG 1379.88), and Figure 13, c, the finished result. Full scale row reductions were made on all the specimens.
The drawings revealed:

- The variability of the head pattern (extent of emargination on the markings, fragmentation of the
  Ɜ−mark, postorbital streak and nuchal collar).

- The consistency of one of the definitive characters for *Macroprotodon abubakeri*, namely the connection between the backward extension of the Ɛ−mark and the postorbital streak: it occurred in all four specimens of *M. abubakeri*.
- The contact between the 6th subralabial with the parietal shield, a variable character in *M. abubakeri*, but not recorded in any *M. cucullatus* from Algeria (WADE, 2001).
- The specimen in Figure 13 (e) was out of keeping with the others in the series. It was assigned to *M. brevis ibericus* on account of possession of an uninterrupted series of 21 dorsal scales and lack of contact between the Ɛ−mark and the postorbital streak.

The head character states typical of *M. brevis ibericus* could have been overlooked, and counts (21 cf 19) would have been erroneously incorporated into the description of *M. abubakeri*.

3.5   MUTILATED SPECIMENS. BUSACK & McCOY (1988) listed a specimen of "*Macroprotodon cucullatus mauritanicus*", MCZ 27500, from El Kreider (N. W. Algeria). Its importance lay in that it was from a region which had not hitherto been sampled. The locality lies on a strip of fertile land bisecting a vast salt lake, the Chott ech-Chergui (map, Figure 24). The specimen had been badly damaged (Figure 14) but it had been preserved whilst fresh and not allowed to desiccate. Aside from residual but adequate elements of the head pattern, virtually all pattern elsewhere had vanished due to spirit fading. The left side of the head was torn at the corner of the mouth and the scale rows were considerably out of alignment, the interstitial skin being very elastic. The scales were often folded or curled inwards along the torn parts. The anterior nape on the right side was also damaged and part of the head was torn. The method used for desiccated and bent specimens could not be applied in exactly the same way but had to be modified and a more fluid/looser approach adopted. The method of reconstruction is described as follows:-

There was a sufficient part of the body intact to enable the position of the first ventral plate (v1) to be located, and the points where the main transverse body scale count of 19 commenced: they occurred at the v8/v7 (left/right) involving the fusion of the 3rd and 4th longitudinal rows on both sides. Irregular scale arrangements may occur dorsally on the head and neck, as in this case; in which the "true" dorsal series followed an apical and three pairs of paravertebral scales. Strategic points of reference were established from the first "true" vertebral scale in the manner depicted in Figure 6; (3.2)

3.5.1   Having noted (drawn) the position of v1, ten scales were counted along the *R* diagonal to, but not including, the vertebral (actually the 9th following the last paravertebral). The position of this scale was vertically aligned to v6; the entire transverse count (including the vertebral) at this point was 21. As there was no immediate evidence of discontinuity in the sizes or direction of the scales (aside from the torn margins) along the corresponding *R* diagonal (from the 9th vertebral to the v1), it was provisionally assumed to be a mirror image. The larger scale marked **y** (the 5th counted from v4)
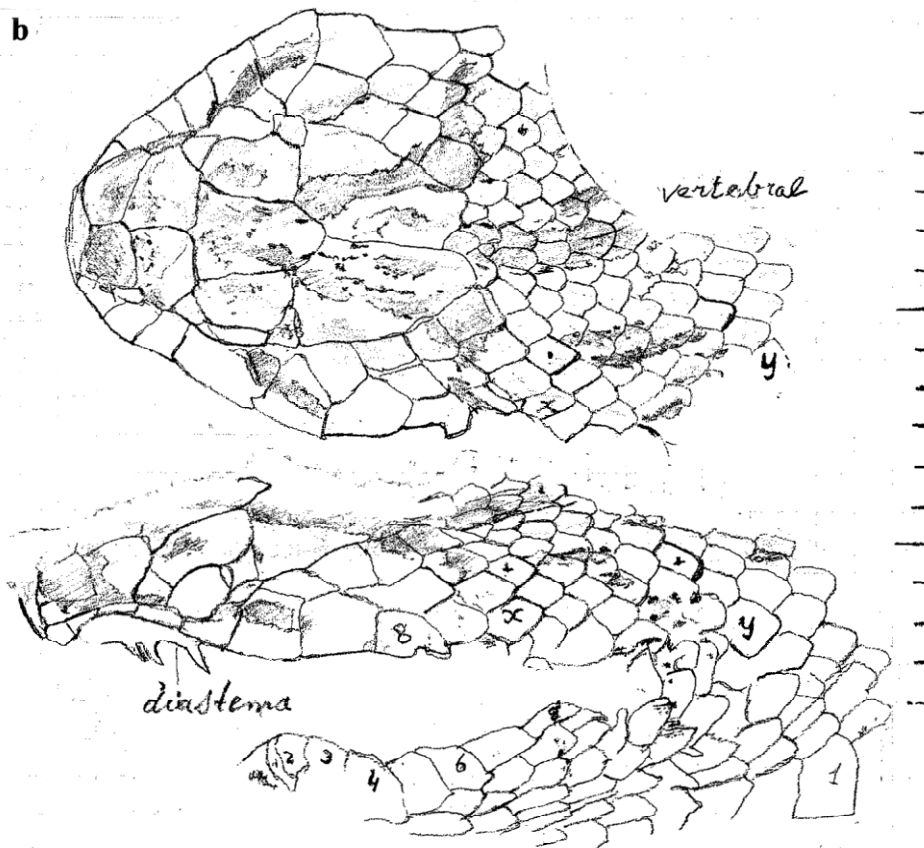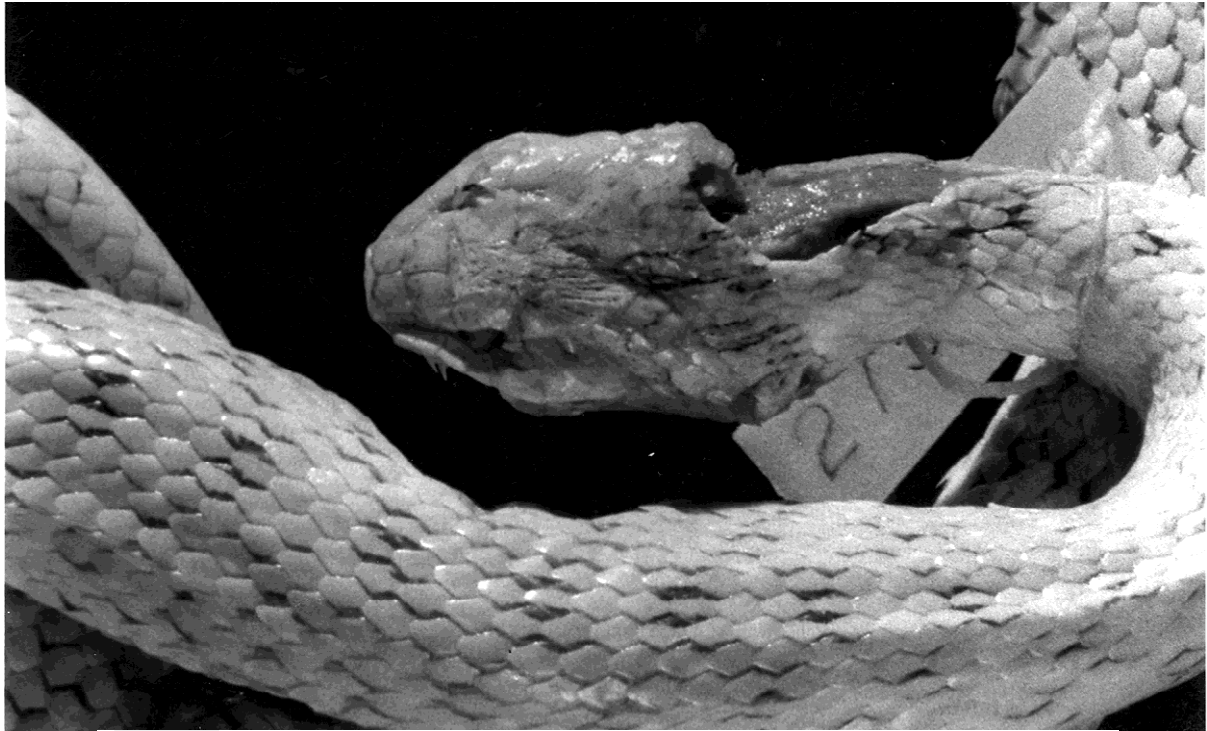
Figure 14. Spirit-faded specimen of *Macroprotodon cucullatus textilis* (MCZ 27500) from El Kreider showing extensive damage. (**a**) Photograph (courtesy Trefor Ball) and (**b**) Drawings with the aid of a stereo microscope using a camera lucida. Scale in millimetres.
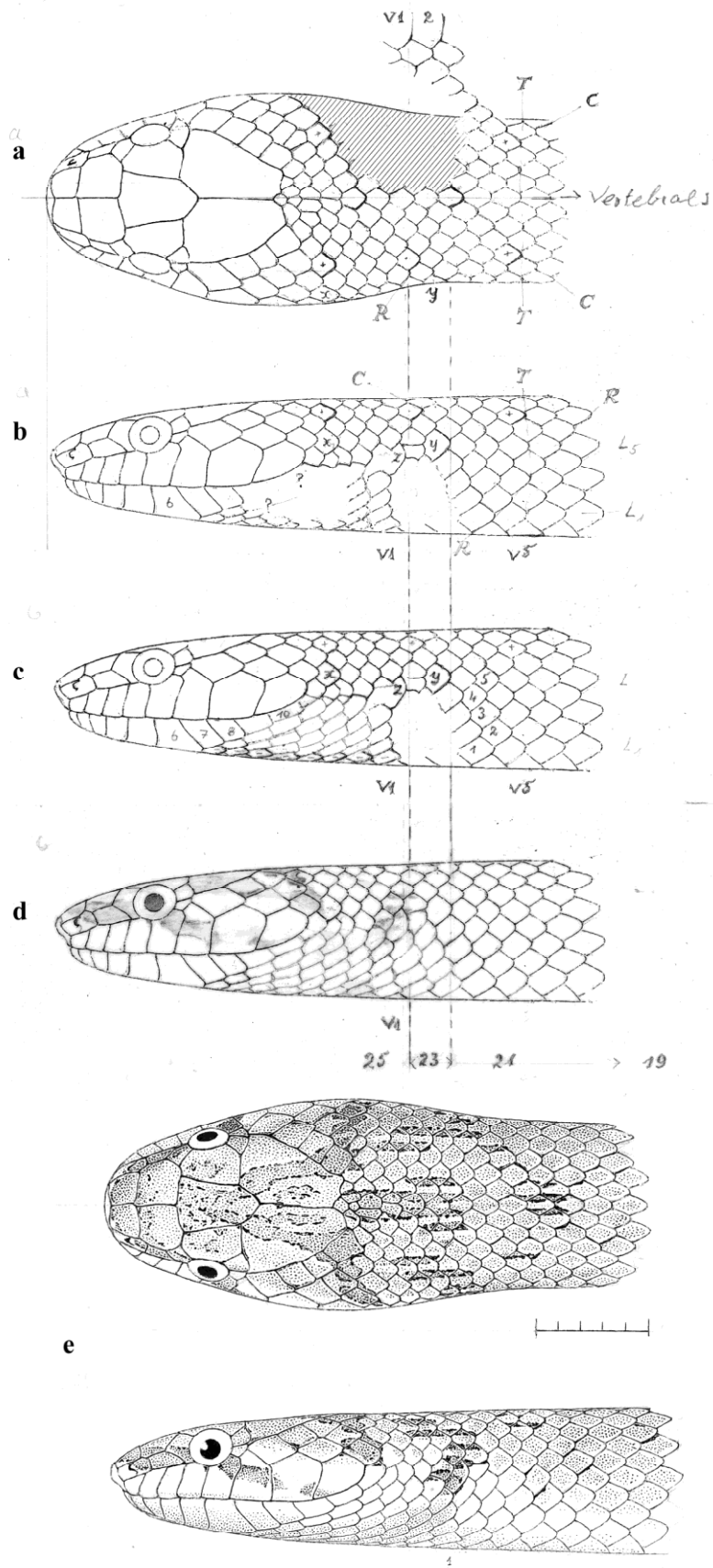
Figure 15. *Macroprotodon cucullatus textilis* (MCZ 27500). Reconstruction of the head in Figure 14, (**a**) and first stage; (**b**) second stage; (**c**) third stage; (**d**) final stage (see text for details); (**e**) finished drawing.

along the **C** diagonal) represents the fusion between rows 5 and 6. The scale marked **z** was longer than deep, and tilted backwards indicating reception of two **C** diagonal rows anterodorsally, and two longitudinal rows anteriorly. Figure 15, a. shows the tentative arrangement of the scales as a result of this step. The area to be resolved being in more or less its proper position, scale rows 1-4 were tentatively placed enabling an anterior and a posterior area to be dealt with.

3.5.2   The anterior area. With regard to the scales in the gular region the **C** diagonal rows are inclined at around 90°, whereas those of the **R** diagonal are less than 30°. Experience (evident from drawings of numerous specimens) has shown that, more often than not, the second, and sometimes the first scale row (as in this case), extends forwards, through the gular region, in a continuous line and terminates as the 6th infralabial.

The infralabial shields following the 8th were unrecognizable. It was provisionally assumed, from experience of drawing many specimens, that the full complement of infralabials was 10 (6+4). Four scales were counted backwards from the last *supralabial* (along the torn margin). By probing the gular scales there appeared to be no obvious irregularities in the direction of either the longitudinal nor the transverse rows. As was initially discernible in the specimen, the 1st scale row contacted the 6th infralabial shield in an unbroken series of 7, labelled *i-vii*, scales between it and v1.
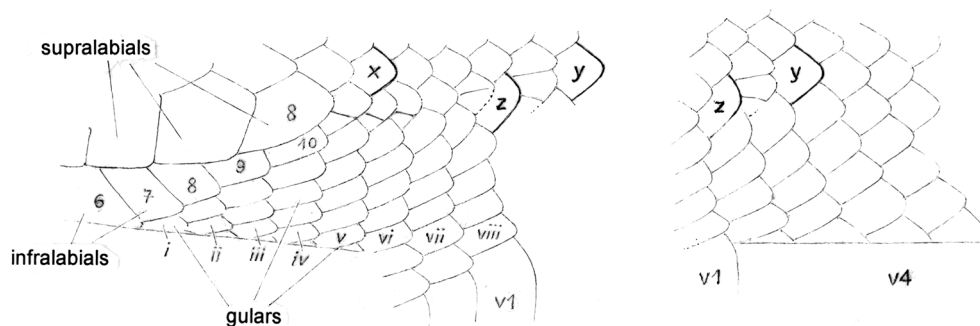
Figure 16. *Macroprotodon cucullatus textilis* (MCZ 27500). Amplification of Figure 15, (b and c). The series of scales following the 6th infralabial at the 1st ventral continues as the 1st dorsal row (usual in *M. c. textilis*; the 2nd row in *M. abubakeri*).

The 7th infralabial was in direct contact with scale *i*; one (cut/torn) scale lay between the 8th and *ii*; two between the 9th and *iii*; three between the 10th and *iv*; four between the scale posterior to the last supralabial and *v*.

The continuum of the row of gular scales from *i* to *v* at which point it is deranged by distension of the interstitial skin (Figure 16, b) but when the scales are matched with reference to the various 'marker' points (see below (Figure 16, a), the line from the 6th infralabial extends backwards to, and abuts the first ventral, continuing as the first scale row.

The post temporal scale **x** divides into two rows of 6 scales each which descend to, and include, *vi* and *vii*. Thus within an area/frame defined by the 6th, and the 10th infralabial, the **x** and *vii* scales, all the scales were in regular formation.

3.5.3   By working forwards from the line (*C* diagonal originating on v1) descending to v4, the scale on the 5th row marked **y** is noteworthy as it receives two longitudinal rows, **x**, and the row below it. The two longitudinal rows immediately below that of **x** (that run backwards from the last supralabial and the [presumed] 10th infralabial respectively) fuse at **z**, which together with the continuation of **x**, run for a short distance (of one scale) to fuse with scale **y**. The connection from **x** along the *C* diagonal to scale *vii* having been established, and the next diagonal series safely assumed to follow likewise to v1, there remained only to link up the diagonal **z** and that which preceded **y** to v2 and v3 respectively.

As the right hand portion was missing, the transverse scale count on the neck made on one side only: it was assumed to commence at 25, reducing to 23 involving the fusion of the 5th + 6th row (**z**), at (i.e. in vertical alignment to) v1; to 21, 5th + 6th (**y**) at v3. Viewed in dorsal aspect, the reductions would barely be visible; symmetry was assumed for the portion where the scales were missing.

The scale row reduction formula is presented below:

```
 (scales missing)  (scales missing)    3+4(7)      3+4(134)     3=3+4(135)    3+4(138)
25------------ 23----------------21-----------19--------------17------------------19------------17----------172v
    5+6(1)         5+6(3)          3+4(8)      4+5(134)     4=4+5(135)     3+4(137)
```

Any error or misrepresentation of positioning or proportion would be apparent. The "order" of the *C*, *R*, *L* rows and *T* axes should match up. Thus, if a scale should be misplaced, the requisite row would be affected and the whole "order" would be disrupted necessitating extensive modifications.

3.5.4   A road kill of an Eastern Montpellier snake (*Malpolon monspessulanus insignitus*) from the region of M'Sila (map, Figure 24) was retrieved in a flattened and virtually shredded state. It was an immature female (Plate III, Appendix II) of 764 (svl 553+tail 211) mm total length and was conspicuously marked: it possessed an anomalous condition of an additional supealabial shield following the third on both sides of the head. The damage was extensive; the head and anterior portion of the neck were torn (the interstitial skin stretched) in numerous places, especially where most of the complications of scale row reductions, fusions and splittings (of *R* and *C* diagonals) occur. The reconstruction procedure was essentially the same as described above (3.5), only it involved incorporation of many more stages. The starting point was the 48th ventral at which the tears on both sides ceased for a distance of three ventrals where a transverse count could be made before resuming caudally on one side or the other, or both). From that point, working towards the head, the interrupted

rows (in all directions) were matched. The multiple tears (Figure 27, marked in crimson) in the critical areas necessitated excercise of extreme caution; "key" scales were identified and marked on the specimen in colours as appear in the figure. The task was considerably eased by having recourse to a compliant live animal (Plate II). A complete scale row reduction formula was recorded. The completed reconstruction is shown in Figure 28.

3.6   PROBLEMATIC SNAKES. The scales on the heads of some species, eg. vipers of the genera *Echis* and *Cerastes*, are often very numerous, and in consequence makes them more susceptible to buckling and distension of the skin when preserved than for the colubrids.

The method of reconstruction is essentially the same, but with more emphasis on the connection (along the ***R***-diagonals) between the last supralabial shield (or the scale immediately posterior to it) to the vertebral series. To establish the anteriormost position of the vertebral scale, a diagonal row from a given ventral should be followed towards a mid point, and reverse along the corresponding row to return to the same ventral: where the counts are the same, the remaining scales are the ventral and the vertebral. The process should be repeated until asymmetry in the scale arrangements on the neck (see above) is reached. This procedure works for most snakes with moderate numbers of midbody scales, which includes most vipers, eg. *Vipera*, *Daboia*, and *Echis*.

The more complex the scalation, as in most boids (boas and pythons), the greater the difficulties encountered, thereby diminishing the likelihood of successful results using the reconstruction methods, particularly when applied to damaged specimens. This also true for specialized snakes with diverging scale arrangements as can be found in the sand-loving vipers, *Cerastes vipera* and *C. gasperettii*, (see above), the African tree vipers (*Atheris*) and some species of *Bitis*. The present writer, nevertheless, was able to reconstruct from a mutilated specimen of *Cerastes gasperettii* (GASPERETTI, 1988. Snakes of Arabia: 334, Fig. 113).

3.6.1   WIDER CONTEXT OF THE WORK. The methods described in the preceeding sections, with appropriate modifications, have proved effective in addressing a variety of taxonomic problems. The three published papers on *Macroprotodon* were the result of these methods, which proved effective in processing quantities of snake material in variable conditions of suitability for drawing.

Characters to which graphic analysis has been mainly directed, i.e. head shields & body scales, during course of illustration were found to manifest a variety of conditions. Some of these, for example states of the head shields and the angles of stacking in body scales in *Rhagerhis*, were revealed as a result of drawing, see Appendix II: Work in Progress.

In *Macroprotodon*, head scutellation, body scale counts; pattern; and maxillary tooth counts were sufficient to assign the specimens to their geographical species and even to populations (WADE, 1988; 2001; CARRANZA et al., 2004). Further research on the genus *Macroprotodon* revealed additional

supporting cranial characters (Figures 20-23) which also show strong indications of being of taxonomic value in *Malpolon* (Appendix II: Work in Progress). Geographical variation was noted for many of the states and species could be defined to some extent in terms of ecology (WADE, 2001; Appendix II: Work in Progress).

Other characters of potential taxonomic value, such as variation in scalation in *Hemorrhois* and *Spalerosophis*, and degrees of divergence in the upper dorsal body scales of *Cerastes vipera*, await examination of greater sample sizes for confirmation, see Appendix III: Characrers useful in Snake Taxonomy.

3.6.2   In the areas where the species of *Macroprotodon* abut there is no evidence of morphological intergradation (WADE, 2001), whereas in three of such localities *Hemorrhois* some of the states of *H. algirus* show some approach to *H. hippocrepis* (WERNER, 1894; BONS, 1967; this work: see below: Appendix II, Work in Progress, Genus *Hemorrhois*, Table 2). Unlike *Macroprotodon* in which the pattern states alter little with age, the distinguishing features between the subspecies of *Malpolon* in Algeria become manifest only when adulthood is well advanced. There is as yet no sure method of matching all specimens to respective subspecies. Groups of diagnostic, principally pattern, states would only be established after adequate sampling of subadult and juvenile material and processed as for *Macroprotodon*. In *Malpolon* the gular and throat pattern is more intimately connected with the scalation, therefore this potentially useful character merits to be faithful recordeding.

Variation in the body scales indicate bioclimatic significance in *Cerastes vipera* (Appendix II: Work in Progress; Appendix III: Characters useful in Snake Taxonomy, Figure 36) and the medically important *Echis arenicola leucogaster* (Figure 32), Appendix II, Work in Progress.

4.0   T H E   P U B L I S H E D   W O R K S

The route which led to the research/publications is described, and an annotated resumé of the published works is presented below.

4.1   FACTORS WHICH LED TO THE PUBLISHED WORKS. The experience of observing snakes in the vivarium acquired over the years, engendered by degrees, an awareness of the scientific aspects of herpetology, and was refined by burgeoning contact both with scientists and access to scientific literature. The interest, as a result, became more focused, identifying an immediate taxonomic problem from which published papers followed.

The example which motivated the present writer's own personal incursion into taxonomy proper, was occasioned by a dispute as to the identity of a live snake *Coronella girondica* (the "true" Smooth Snake) or *Macroprotodon cucullatus brevis* (the False Smooth Snake), said to have originated in "Spain". The sequence of events leading to the publications is detailed below.

Up to 1988, the genus *Macroprotodon* comprised a single species (*M. cucullatus*) with two ill-defined races, *M. c. cucullatus* and *M. c. brevis*. The two forms are superficially similar in appearance and are sometimes confused (WADE, 2001:95 and also see Appendix III: Characters useful in Snake Taxonomy.

4.2   *MACROPROTODON* COMPARED WITH *CORONELLA* IN SPAIN. In the Iberian Peninsula the two species may be distinguished by a variety of morphological features. They share the condition of smooth scales in 21 rows and 8 supralabial shields but *Coronella girondica* differs from *Macroprotodon brevis ibericus*) by the possession of a pale centred nape mark as opposed to an undivided "collar", a subocular sutural mark and a straight posteroventrally directed postorbital stripe, as opposed to one which is angled (Figure 17) and two (occasionally three) elongated anterior temporal as opposed to a large single shield, which is often excluded from contact with the lower postocular shield by the labial-parietal contact. A whole specimen of *Coronella* "*amaliae*" [=*C. girondica*] from Tangiers is figured in the lithographed plate (Figure 4, 1a). With regard to characters of the skull, *Coronella girondica* has an even row of marginal, i.e. maxillary and mandibular teeth lacking fangs (Figure 22, a) whereas in *Macroprotodon* fangs are present and the series of teeth are unequal in size and are separated by diastemata (gaps between rows of teeth) (Figure 22, b).

The specimen in question was unusual in that it possessed 19 midbody scales as opposed to the 21 scales, 9 as opposed to 8 supralabials of which none were in contact with the parietal shield. It however, possessed fangs and diastemata between the tooth rows on the maxilla and mandible, and was consequently assigned to the Balearic form of *Macroprotodon cucullatus*, now known as *M.*
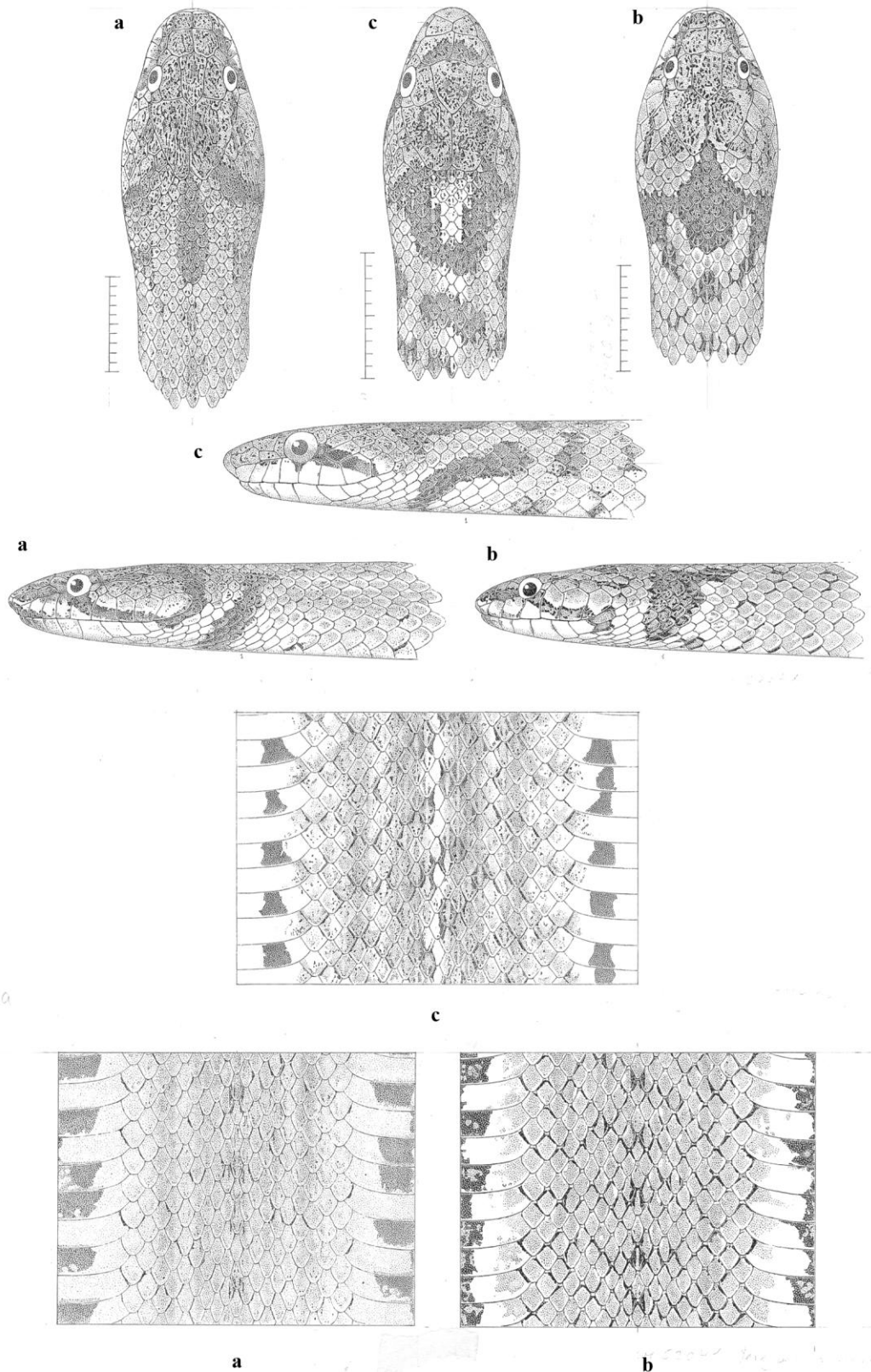
Figure 17, (**a**) Head+mid-body scalation of Smooth and False Smooth Snakes. (**a**) (*Macroprotodon mauritanicus*) from Majorca (N. Smith, private collection), (**b**) *Macroprotodon brevis ibericus* paratype (CM 52041) from Jerez de la Frontera and (**c**) the true smooth snake (*Coronella girondica*, USNM 56437) from Algiers (the size of the rostral shield viewed dorsally is variable in this species: in the Iberian form it is much less prominant, similar to that of *Macroprotodon*). Scale in millimetres. The "pelts" at mid body are not to the same scale.

Species	*Coronella girondica*	*Macroprotodon brevis ibericus*	*Macroprotodon mauritanicus*
Provenance	IBERIA	IBERIA	BALEARIC ISLANDS
Transverse scale count	21	21 (occasionally 19, rarely 23)	19
Supralabial count	8	8 (occasionally 7)	usually 9
Nape marking	pale centred	undivided nuchal collar	divided nuchal collar
Subocular sutural mark	present	absent	absent
Postocular stripe	straight	Lightly angled	Short (rarely beyond 6th supra-labial), rarely complete *
Anterior temporals	2 (or 3), long	single, short	Irregular, usually single
Maxillary teeth	undifferentiated, lacking grooved fangs and diastemata	Strongly differentiated, grooved fangs and diastemata present	Strongly differentiated grooved fangs and diastemata present

Table 1. Principal characters which define *Coronella girondica* and the species of *Macroprotodon* in Iberia and the Balearic islands. *It is complete, i.e. extends beyond the labial shields, in the specimen shown in Figure 4, a.

mauritanicus (WADE, 2001; CARRANZA et al., 2004). Examination of a greater number of specimens of both *Macroprotodon* species, *M. brevis* and *M. mauritanicus*, from Iberia and the Balearic islands respectively, showed the differences to be consistent (Table 1).

4.3   STUDIES ON *MACROPROTODON*. The taxonomic position of *Macroprotodon* in Iberia and the Balearic islands having been clarified, an appraisal of the genus throughout its range was conducted. A total of 90 specimens, mainly from the Natural History Museum was examined: the subspecies *M. c. mauritanicus* was described and given formal recognition (WADE, 1988).

BUSACK & MCCOY (1990) using Discriminant Function Analysis (BMD07M) presented a different morphological concept of the genus and described an additional subspecies *M. c. ibericus*. Whilst there was agreement on the presence of *M. c. mauritanicus* in Algeria+Tunisia, there was disagreement as to geographical limits, see WADE (1988, maps, Fig. 6; 2001, maps, Figs 1, c. & 10) BUSACK & MCCOY (1990, map, Fig. 1). The present writer examined a much larger number of specimens, 157 from Algeria alone, including those upon which BUSACK & MCCOY (1990) based their conclusions.

The impetus to expand the investigation came from a loan by the Natural History Museum in Geneva which included a black headed specimen (MHNG 1379.68, Figure 18, a) purportedly collected from Bordj Bou Arréridj (map on Figure 24). It had the unusually high transverse midbody scale count of 23 as opposed to 19 which is usual in that region. Intensive collecting revealed only two further black headed specimens (Figure 24, b & Plate I), which, however, were assignable to *Macroprotodon* [*cucullatus*] *mauritanicus* in *all* other respects. As a result of examination of numerous specimens from Morocco the MHNG 1379.68 specimen was subsequently placed with the Essaouira-Marrakech
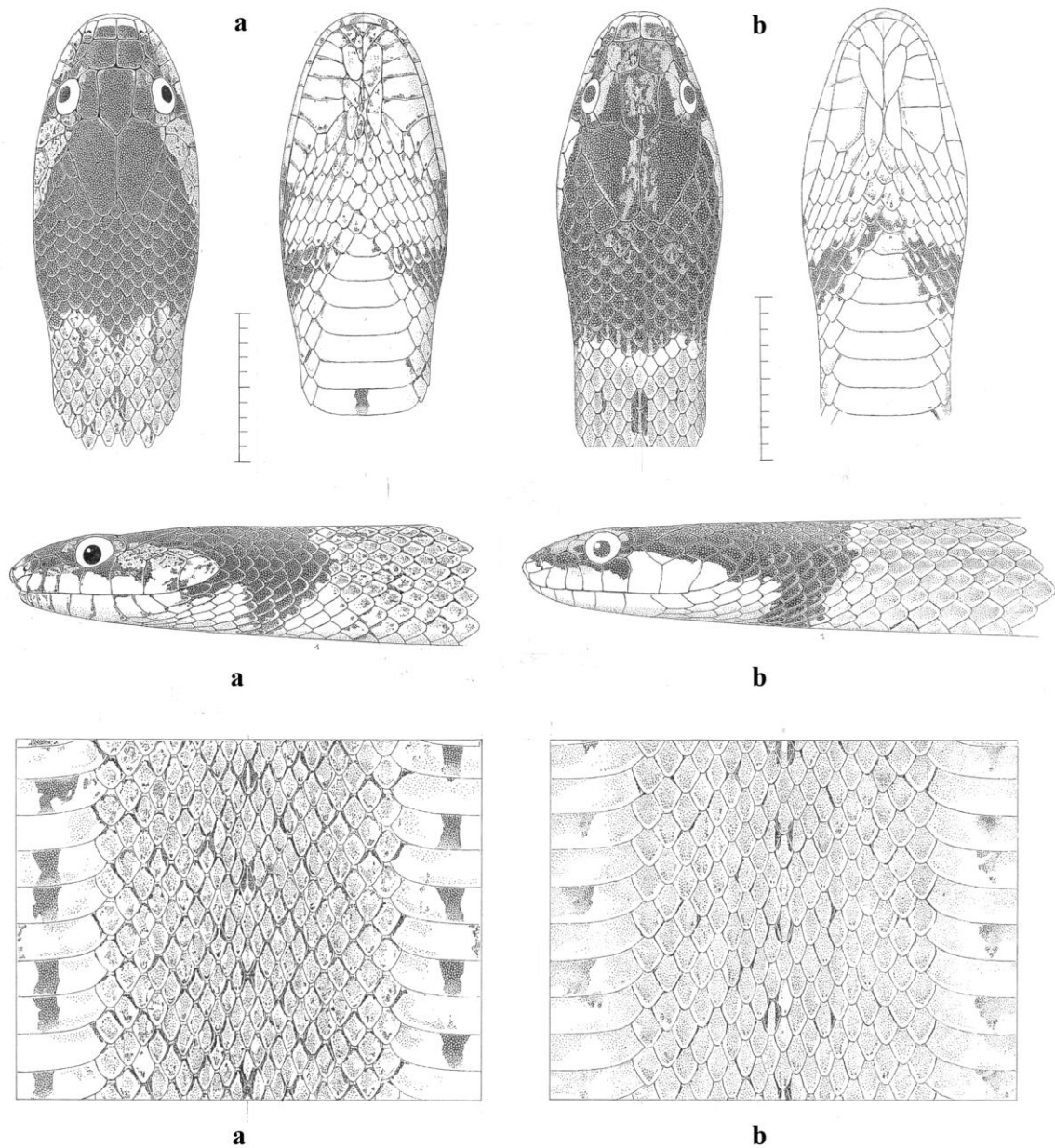
Figure 18. (**a**) *Macroprotodon brevis* (MHNG 1379.68), a black headed specimen from Bordj Bou Arréridj showing the high midbody scale count; (**b**) *M. mauritanicus* from Médjana in the same wilaya (partly after WADE, 2001): black headed morphs in this species have been found only in this region. Scale in millimetres. (Scalation at mid body not to the same scale).

populations of *Macroprotodon brevis*. It was concluded that it probably represented an accidental introduction or an error of attribution.

Pictorial references, mostly photographs from literature, of specimens from areas where *Macroprotodon* populations were not satisfactorily assigned to any species, rarely gave the desired amount of detail. However, the illustrations of *Macroprotodon* in JAN & SORDELLI (1866; livraison 19ᵉ, Pl. I) provided enough detail for identification.

Plate I. *Macroprotodon mauritanicus*. The second example the black-headed condition recorded for this species. Specimen from Médjana (W. de Bordj Bou Arréridj), Algeria (Photographs courtesy of Dr P. Stafford).

The black headed specimen depicted in Figure 19,a (=3A), *Psammophylax* [=*Macroprotodon*] *cucullatus* from Biskra, although no longer extant (see above, 2.3.1), was readily identified by the body markings and the detail in the subsidiary figures (Figure 19, a=3A, *a-f*). The figure was fortuitous as it was of a specimen from a locality where *M. cucullatus* and *M. mauritanicus* abut.
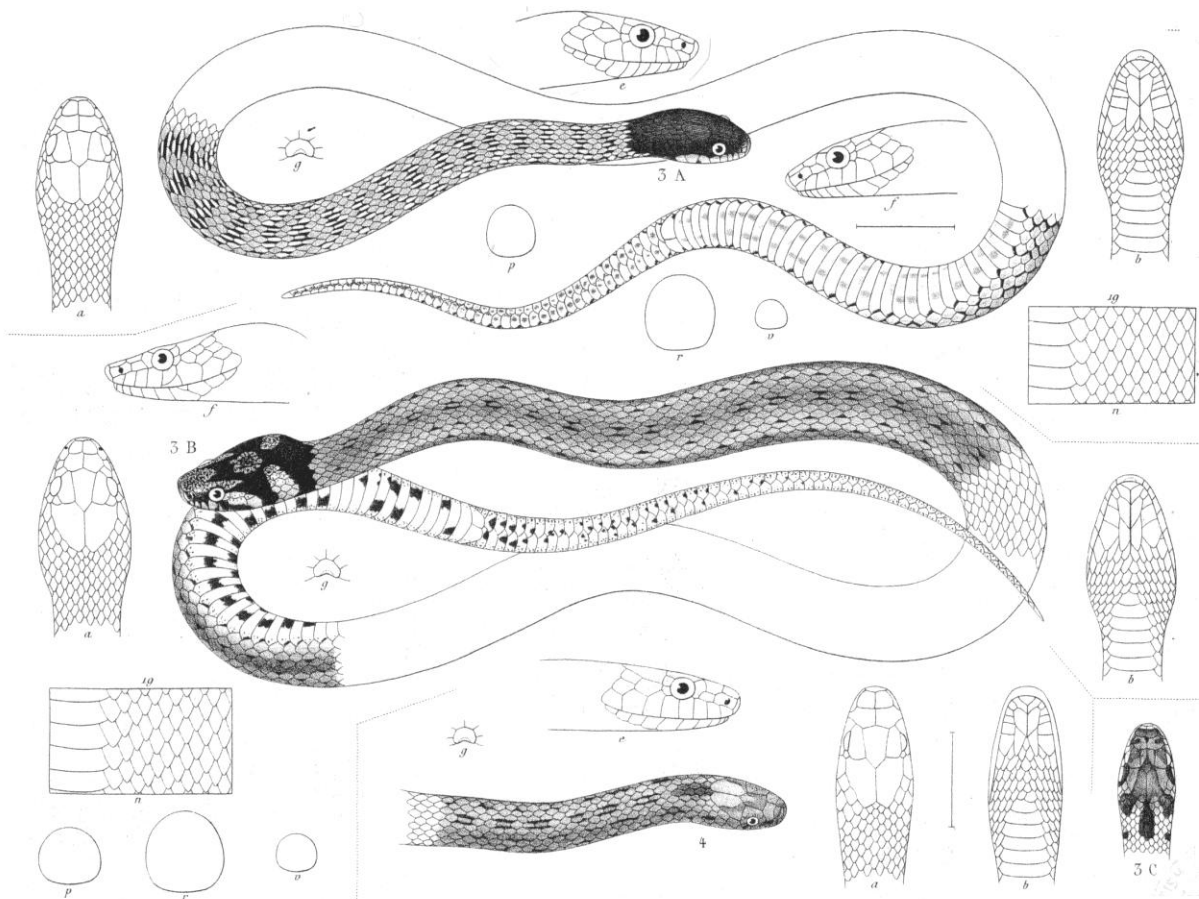
Figure 19. *Macroprotodon* spp. Line engravings from JAN & SORDELLI (1866). 19e Livraison, part of Pl. I, 3A, a-f *Psammophylax* [=*Macroprotodon*] *cucullatus* cf *textilis* from Biskra (Algeria). 3, B, a, b *Psammophylax cucullatus* [=*Macroprotodon mauritanicus*] from Bejaïa (Algeria). 3C from Egypt. 4, a-e *Psammophylax* [=*Macroprotodon*] *cucullatus textilis* from Algeria ?holotype.

The specimen depicted in Figure 19, d (=4 in JAN's list) "*id var textilis*," from "Algérie", was similarly assigned to *M. cucullatus*, and as it was from the Paris Museum, could well be an illustration of the holotype of *Lycognathus* [=*Macroprotodon cucullatus*] *textilis*. Although the scales were simulated, the head plates conformed to the specimen (compare with Fig. 3, a, of WADE, 2001).

Figure 19, b=3B shows a rare variant of *M. mauritanicus* from Bougie, Berbérie (=Bejaïa, N. E. Algeria), in which the ∧-mark, temporal streak and nuchal collar were connected; it is seen as an early progression to the black-headed condition (see above Plate I & Figure 18, b).

The mass of accumulated data and drawings from North African *Macroprotodon* material, supplemented by observations in the field, resulted in the publication of a taxonomic review of the

genus in Algeria (WADE, 2001), and the morphological base for the molecular paper of CARRANZA, ARNOLD, WADE & FAHD (2004). These two papers, together with a table summarizing the characters (Appendix I), were an appraisal of the genus, and the latter, a summary throughout its entire range. During subsequent visits to Algeria more material was collected for future study on *Macroprotodon* and also on other species (see below, Appendix II: Work in Progress).

4.4   EXPANSION INTO WIDER AREAS OF HERPETOLOGY. Whilst in Ghana in 1968 the present writer met Barry HUGHES, then of the Zoology Dept. at Legon University whose main interest was West African snakes. As the present writer's field of study was mainly North African snakes, as the area of interest of both overlapped in the central Sahara and a number of species are common to Algeria and West Africa, collaboration naturally followed. Probably Africa's most taxonomically confused genus *Psammophis*, particularly the *Psammophis "sibilans"* complex, in reality comprising a number of species distributed throughout Africa. Together with HUGHES the present writer published two papers and one on forms which had hitherto been considered varieties of *Psammophis sibilans*: one in which a new species, *P. zambiensis* has been described (HUGHES & WADE, 2002), and the other in which the status of the type specimens of *P. phillipsi phillipsi* and *P. p. occidentalis* has been determined (HUGHES & WADE, 2004).

Salvador CARRANZA, a molecular biologist, specializing in the evolution of Mediterranean herpetofauna teamed up with the present writer during his period at the Natural History Museum, London. Together they worked on Spanish-North African newts of the genus *Pleurodeles*: this resulted in a joint paper on the Algerian newts (CARRANZA & WADE, 2004) involving the respective disciplines of both writers.

4.5   **REFLECTIONS ON THE PUBLISHED WORKS.** The published papers to a large extent reflect a natural affinity of art with morphology, and more implicitly, that drawing can be used as a tool for inquiry, as opposed to just illustration. The discovery of the scale grouping method enabled large numbers of specimens to be visually processed, and thereby addressed characters less easily quantifiable taxonomically and facilitated the discovery of the method of reconstruction, which itself contributed to the result of a morphological definition of *Macroprotodon* in the two published works and also to a third paper, tabulated in Appendix I.

4.5.1   BRANCH, W. R. & E. O. Z. WADE. 1976. Hemipenial morphology of British snakes

This paper marked the beginning of the present writer's involvement with taxonomy, and represented a starting point with a view to future investigation of this character. The method of wax impregnation of the specimens (other than mere fixation) was perfected and opened up the prospect of drawing in detail complicated soft structures which would otherwise shrink when removed from the preserving fluid.

DOWLING, 1960, 1967; UNDERWOOD, 1967a, 1967b had demonstrated the importance of hemipenes in snake systematics (these structures, by virtue of being least influenced by the natural forces of evolution, the mating procedure being essentially the same for snakes, are therefore more reliable indicators of affinities). In addition to the vipers two subfamilies of colubrids the natricines (watersnakes) and colubrines (smooth snakes, ratsnakes etc.) are represented hemipenially. The present writer found unexpected hemipenial states in two colubrine species, *Macroprotodon cucullatus* and *Hemorrhois hippocrepis* (see below, Appendix III, Characters useful in Snake Taxonomy).

4.5.2   WADE, E. 1988. Intraspecific variation in the colubrid snake genus *Macroprotodon.*

In this paper the scale grouping method (see above 3.1) was applied and adapted in response to problems of analysis presented by the wide variation in character states, to record and process the visual data in large numbers of specimens documenting unrecorded characters and/or their states; head and body pattern was used for the first time in the analysis for this genus. Selected specimens, irrespective of the position and condition of preservation, were reconstructed and portrayed in the same position for easier comparison.

Differences between the Balearic and Iberian false smooth snakes were highlighted (see Table 1, Appendix I and Figure 17, b & c). The study was expanded to include the species in North Africa. Unlike in Spain and the Balearic Islands, the pattern states which defined the forms could not be relied upon when material from North Africa was considered, additional characters therefore were investigated. The two long established races were redefined in terms of meristic characters and conditions of head and body pattern. The Balearic form was identified with the populations of Northern Algeria and Tunisia which were described as a new subspecies.

4.5.3   WADE, E. 2001. Review of the False Smooth snake genus *Macroprotodon* (Serpentes, Colubridae) in Algeria with a description of a new species.

In this work the process of recording by drawing, developed during the preparation of WADE (1998) was refined; and by applying the method of grouping, and reconstruction (see above 3.2 and 3.3) visual data about 90% of the specimens analysed were visually profiled, with the resulting confidence of having access to unrecognized features as and when the occasion warranted. The reconstructive methods and the accumulated visual data, with the exceptions of the illustrations in the paper (as for the work of 1988) in accordance with convention in such publications, were not included.
The false smooth snakes of Algeria and adjacent territories were reappraised. To the three taxa *M. c. brevis*, *M. c. cucullatus* and *M. c. mauritanicus*, a fourth (*abubakeri*). and were redefined morphologically and bioclimatically and raised to full species. The Iberian race *M. c. ibericus* Busack & McCoy (1990) was retained as a subspecies of *M. brevis*, but its distribution extended into northern Morocco as far west as Larache and as far south as Fez. Further south the demarcation line between

the ranges of *M. b. ibericus* and *M. b. brevis* are unclear and the morphological character states of the two races appear to intergrade.

A total of 192 specimens, 51 of *M. cucullatus*, 83 of *M. mauritanicus*, 31 of *M. abubakeri* and 27 of *M. brevis ibericus* from Morocco, were examined and analysed. New characters together with those already used (WADE, 1988) including some discarded by BUSACK & MCCOY (1990), in the main supported the conclusions in the present writer's earlier paper of 1988.

4.5.4   HUGHES, B. & E. WADE, 2002. On the African leopard whip snake, *Psammophis leopardinus*, Bocage, 1887 (Serpentes, Colubridae), with the description of a new species from Zambia.

The illustrations were of two individuals of strongly contrasting patterns, an adult in good condition and a juvenile in a shrunken state. As the heads and necks of the specimens had been preserved in more or less the same position, the only reconstruction considered desirable was some "filling" out on the juvenile, and ensuring that the views of any of the scalation on any part of the head and throat would be the same in both specimens. The grouping method (3.2) was of use in the positioning of the scales, especially the ***T*** series and those of the midbody.

Psammophis sibilans Linnaeus comprises a complex of several 'forms' with those with distinctive reticulate markings on the anterior portion of the body (*leopardinus*-pattern) having been assigned to separate races: the Zambian specimens to *P. brevirostris leopardinus* (BROADLEY, 1971:88; BRANDSTÄTTER, 1995:53 etc) with the Angolan and Namibian material retained as *P. leopardinus* (HUGHES, 1999). Lower tooth and scale counts served to distinguish the Zambian from the other reticulate-patterned forms and it was named as a new species, *Psammophis zambiensis*.

4.5.5   HUGHES, B. & E. WADE 2004. Is *Psammophis sibilans occidentalis* Werner, 1919 a junior synonym of *Psammophis phillipsi* (Hallowell, 1844)? (Squamata, Serpentes, Colubridae).

The specimen illustrated was in excellent condition and aside from smoothing over some irregularities, no further treatment was considered necessary.

Whilst examining the collection in the Vienna Museum HUGHES found two Congolese specimens [in the same jar], labelled "*Psammophis sibilans*" and "*Psammophis sibilans occidentalis*" respectively; the latter was described as a *var*. [=*variety*] by WERNER (1919). The authors followed BRANDSTÄTTER (1995) in associating them with *P. phillipsi* rather than *P. sibilans*. The var. *occidentalis* was accorded subspecific status whereas its companion was assigned to *P. phillipsi phillipsi* albeit with rather atypical markings. The status of a related form *P. irregularis* Fischer was discussed.

4.5.6   CARRANZA, S & E, WADE, 2004. Taxonomic revision of Algero-Tunisian *Pleurodeles* (Caudata: Salamandridae) using molecular and morphological data. Revalidation of the taxon *Pleurodeles nebulosus* (Guichenot, 1850).

The main artistic contribution was 3-dimensional; it involved making plasticine casts of difficult to access, but taxonomically important tooth rows from which drawings were made.

Until 1953 the Algerian newt genus *Pleurodeles* comprised two species, *P. poireti* (Gervais) and *P. hagenmulleri* (Lataste). These two species were synonymised by PASTEUR in 1958. Molecular analysis showed the two forms to be distinct. Morphologically, the species can be differentiated by size, head shape, the state of the palatine tooth rows and in colouration. The more widespread form commonly referred to *P. poireti* (Gervais, 1835) was given the name *P. nebulosus* (Guichenot, 1850), and *P. poireti* replaced *P. hagenmulleri* (Lataste, 1881) for the newly resurrected species from Annaba.

4.5.7   CARRANZA, S., E. N. ARNOLD, E. WADE, S. FAHD, 2004. Phylogeny of the false smooth snakes, *Macroprotodon* (Serpentes, Colubridae): mitochondrial DNA sequences show European populations arrived recently from Northwest Africa.

The morphological input by the present writer is summarised in Table II, (Appendix I) in which the distinctive characters of each species throughout their range are detailed. The definitions relied on accumulated reconstructed drawings, not only from those which had contributed to the two previous *Macroprotodon* papers, but also from material from the entire distribution of the genus.

As part of the molecular survey of the Mediterranean herpetofauna *Macroprotodon* was investigated with regard to the validity of the taxa then recognized (WADE, 2001) and the historical period in which they became established.

The DNA gave conflicting results from the morphology. In terms of its mtDNA, *Macroprotodon cucullatus* cf *textilis* is a complex of species. Samples of *M. cucullatus* from Morocco were found to be identified genetically as *M. brevis*, and *M. mauritanicus* from Mallorca, Algeria and Tunisia were indistinguishable from *M. cucullatus* from Tunisia. The distinctness of *M. abubakeri* and the presence of *M. brevis ibericus* in Morocco were confirmed.

Much remains to be done: with regard to morphology cranial characters are being addressed (Appendix II, Work in Progress); the genetic picture is far from complete, extensive areas remain unsampled.

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7.0   A P P E N D I C E S

I: MORPHOLOGICAL CHARACTERS OF MACROPROTODON

Character	State	Macroprotodon brevis ssp — brevis	— ibericus	M. abubakeri	Macroprotodon mauritanicus — BALEARIC form	— N. AFRICAN form	cf textilis	Macroprotodon cucullatus ssp — cucullatus
No. of Dorsal scales at midbody	19		+ (N. Sp)	+++++	+++++++	+++++	+++++-	+++++(+)
	21-19	+++++ (Mor)	++++ (Sp)	+++	+	++	-	+
	21	+++++ (Mor)	++++ (Sp)	-	-	-	-	-
	21-23	++++ (Mor)	++++ (S. Mor)	-	-	-	-	-
	23+		+	-	-		-	-
No. of Supralabials	7	-	++ (Sp)	-	-	-	-	-
	8	+++++	+++++	++++++	+	++++++	+++++++	++++++
	9	?	+ (Mor)	-	+++++	+	-	-
No of Infralabials	6+3	+++++ (N. Mor)	+++++	++(+)	+	++++	+ (SAH. OCC. & HOGG)[1]	++++
	6+4	++ (S. Mor)	++	+++++(+)	+++++	+++	+++++	++
Supralabial/Parietal contact	+ sutural contact	++++ (N. Mor)	+++++	+++	+	++++(+)	-	++++
	+- point contact	?	+	+++++	-	+	-	-
	- no contact	+++++ (S. Mor)	++	+++	+++++	++	+++++	+++++
Body pattern	undifferentiated or striated	++++ (N. Mor) / ++++ (S. Mor)	+++++	+++++	+++++++	++++++	+[3]	+[4]
	reticulated (="textilis")	-	-	+	-	-	++++	+++++
Nuchal collar	entire	++++ (N. Mor)	+++++	+++++	+	+	na	na
	divided	++++ (S. Mor)	+	++	+++++	+++++		
	connected to postorb. str	++	++	++	+++++	+++++		
	separate from postorb. str	++++(+)	++++	+++++	+	-		
Pale collar	+ present	+++++	+++++	+++++	+++++++	+++++++	+++ (incr. westward)	-
	- absent	-	-	-	-	-	+++ (incr. eastward)	na
	nuc. col/postorb. str. conn.	-	-	++++	++++ (MENORCA)	-	na	na
	melanocephalism	+++++	++	++	-	+	++++(+)	++++ (50%)
Postorbital streak	short	-	-	-	-	-	-	-
	entire or variable	+++++++	++++++	++++++	+++++	++++(+)	+++++(+)	+++++(+)
Maxillary teeth	6+5+II	+++++++ (S.Mor)[2]	++++++	-	+	++(+)	+++++ (east)[1] / +++++ (west)	+++++
	6+4+II diastema short	++	+	-	-	-		++
	6+4+II diastema wide	++++	+++++	++++++	-	-		+
	6+3+II	+	+	-	++ (MENORCA) / ++++	++++++	-	-

Table 2: Summary of the main morphological characters and states of the genus *Macroprotodon*, in association with and as summarised in map, Fig. 1, CARRANZA et al. (2004)

Arbitrary scale for the frequency of the character states.

-   unknown
+   rare
++   uncommon
+++   occasional
++++   frequent
+++++   usual
++++++   100%
Significant states. in **bold** type.

Abbreviations

Sp Spain
Mor Morocco
Alg Algeria
Tun Tunisia
N north of range
S south of range
incr increasing in frequency

[1] including the populations of *M. c. cf textilis* from Sahara Occidental and the Hoggar (Algerian central Sahara).

[2] the populations of *M. brevis* south of the O. Souss (Mor).

[3] ground colour disposed in "striated" manner (n=1, Ksar Chellala, Alg; n=1, Bou Chebka, Tun), but distinct from that of scale row 1 and belly hence considered essentially "textilis".

[4] reduction of "reticulated" markings and pale interspaces in Lampedusa (n=5) and Libya (n=2) giving a superficially undifferentiated appearance : assigned to "textilis" on basis of ground colour not extending to scale row 1 and agiacent part of belly.

II: WORK IN PROGRESS

The published papers (see above) are the "tip of the iceberg" of a much more detailed study. Data and material is continually being amassed from fieldwork, institutions and other sources. Further investigation of *Macroprotodon* is being conducted not least as a response to challenges posed by recent molecular studies. The genera *Malpolon*, *Rhagerhis*, *Psammophis*, *Hemorrhois* and *Echis* are similarly are addressed in respect of which reconstructions are essential. Roadkills afforded opportunities to extract cranial data. Expansion into the Tropical African snakes is undertaken in collaboration with B. HUGHES on *Rhagerhis* (in preparation): work West African *Psammophis* is in progress, particularly in the Sahara-Sahel zones of transition.

FAMILY COLUBRIDAE.

Genus *Macroprotodon*. CARRANZA et al. (2004), as a result of mitochondrial DNA sequencing, presented a conception of distribution of *M. mauritanicus* and *M. cucullatus* which conflicted with that of WADE (2001). DNA from tissue from specimens of *M. cucullatus* cf. *textilis* from Amersid (upper Moulouya valley, E. Morocco) were aligned with the parapatric *M. brevis*. DNA from *M. mauritanicus* material from Médjana (N. Algeria), Tabarka & Aïn Drahm (N. Tunisia) showed greatest genetic similarity with *M. cucullatus* from Bou Chebka, S. Tunisia, which themselves were placed close to the *M. c. cucullatus* from El Agheila, Libya.

Since CARRANZA et al. (2004) further collecting in unsampled regions, *M. cucullatus textilis* from the Algerian steppes, *M. abubakeri* from the northwestern part of the country, in essential characters of scalation and dentition (Tables. 3 & 4), reinforced the the conclusions of WADE (2001). *M. cucullatus*
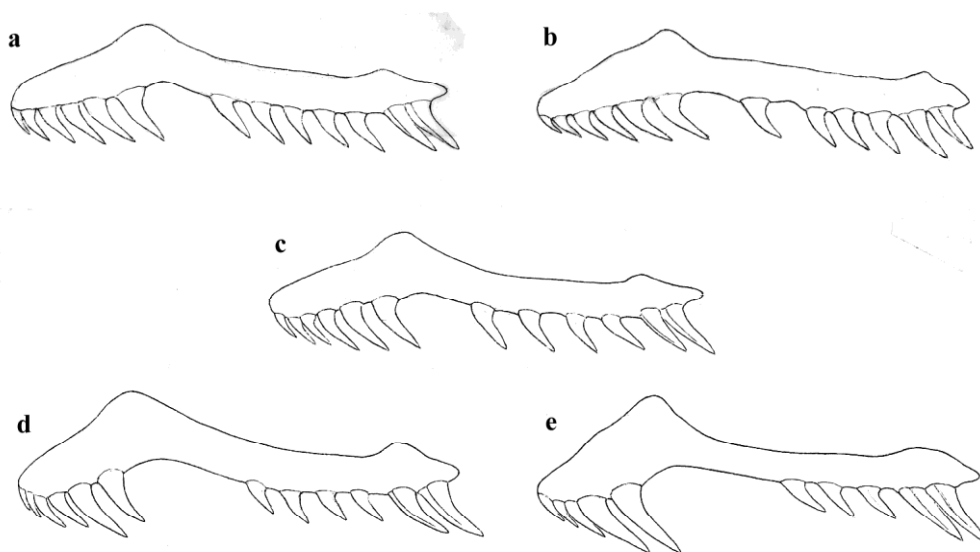
Figure 20. Left maxillae. (**a**) *Macroprotodon cucullatus cucullatus* (BMNH 1903.6.18.16) from Maryut, Alexandria; (**b**) MNHN 849, holotype of *Lycognathus textilis*; (**c**) *M. c. textilis* from El Bayadh (IPA 197), (**d**). *M. abubakeri* from Ksar Chellala (IPA 241), (**e**). *M. mauritanicus* from Batna (BMNH 1920.1.20.1525)
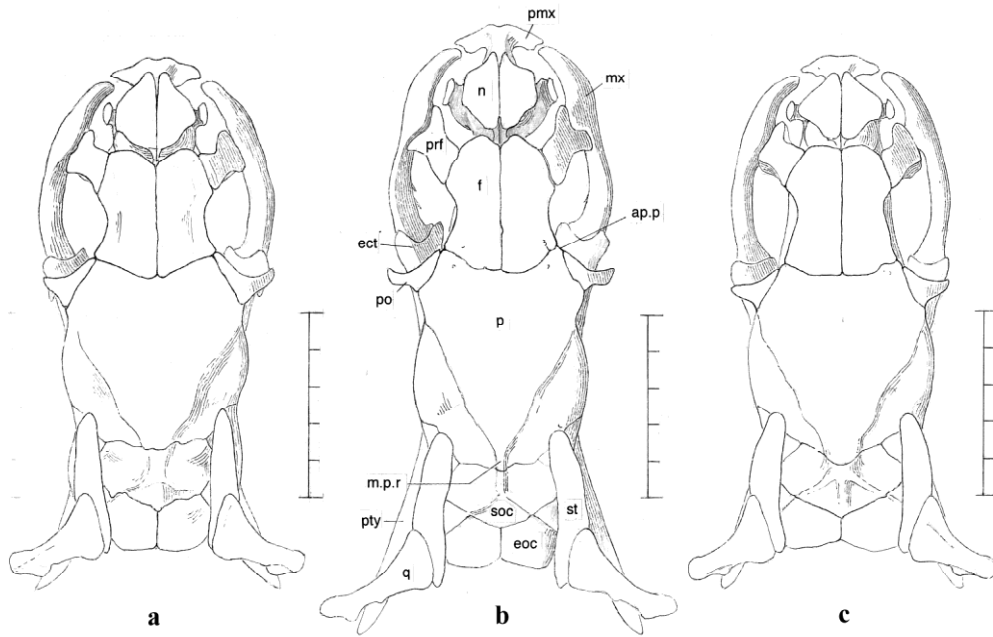
Figure 21. Dorsal aspects of the skulls of (**a**) *Macroprotodon cucullatus textilis* (IPA uncatalogued), Sidi Djillali; (**b**) *M. mauritanicus* (Batna (BMNH 1920.1.20.1525); **c**. *M. c. cucullatus* Maryut, Alexandria (BMNH 1903.6.18.16). **app**, anterolateral process of parietal; **ect**. ectopterygoid; **eoc**, exoccipital; **f,** frontal; **mx**, maxilla; **n**, nasal; **p**, parietal; **pmx**, premaxilla; **po**, postorbital; **prf**, prefrontal; **pty**, pterygoid; **q**, quadrate; **soc**, supraoccipital; **st**, supratemporal.

cf. *textilis* populations from Eastern Morocco, irrespective of DNA resembled those from in the

Data from skulls provided further support. The skulls of *M. c. textilis* (Sidi Djillali, Algeria), *M. c. cucullatus* (Maryut, Egypt), *M. mauritanicus* (Batna, Algeria) and *M. b. ibericus* (an alizarin preparation from Cadiz Province) are similar. There are, however, significant differences: the premaxilla-maxillae articulations in both *M. mauritanicus* (Figure 22, b) and *M. brevis ibericus* (personal observation) are more closely fitting than in the *cucullatus ssp.* (Figure 22, a & c). The skull of *M. mauritanicus* also differs from that of the other species in the following respects. The dorsal process of the maxilla is conspicuously "humped" and has a greater area of contact with the prefrontal at the position of articulation. The last two maxillary teeth in the first series are stout and strongly enlarged and provide maxillary-prefrontal support (ANTHONY, 1955:32) contributing to the success in

Species	*M. brevis*	*M. abubakeri*	*M. mauritanicus*	*M. c. textilis*	*M. cucullatus*
Provenance	MOROCCO (Middle Atlas)	N.E. MOROCCO-N. W. ALGERIA	N. E. ALGERIA + TUNISIA	E. MOROCCO to S. TUNISIA	S. E. TUNISIA-EGYPT
Midbody scales	**21-23**	**19** (21)	**19** (20)	**19**	**19**
Supralabial/parietal contact		++ & --	+++	--	-- & ++
Posterior infralabials	**3-4**	**4** (3)	**3** (4)	**4**	**3-4**

Table 3. Summary of the principal scale characters in *Macroprotodon* spp. Symbols=arbitrary scale from slight contact + to very pronounced ++++; -- no contact. States in parentheses= occasional or rare occurance.
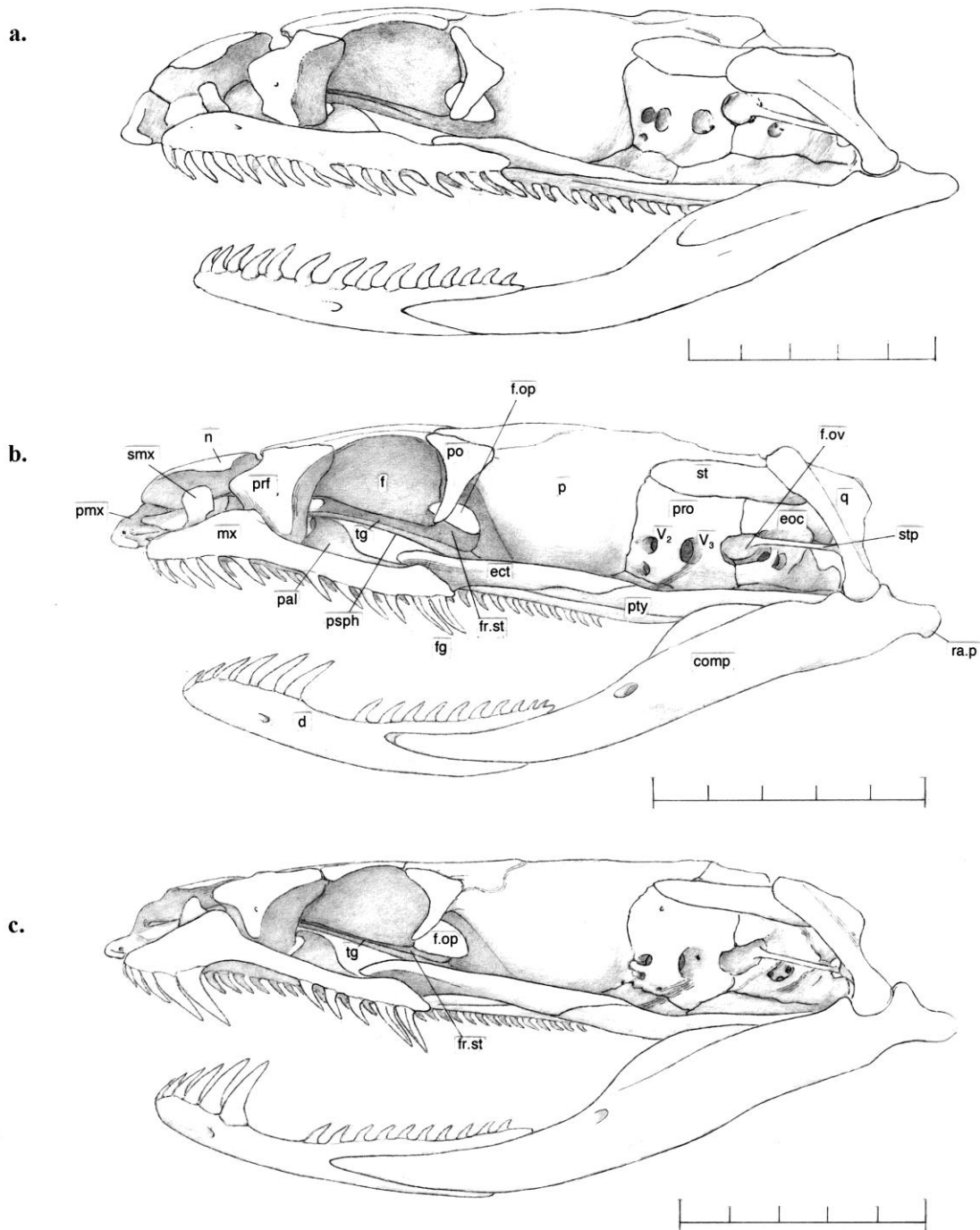
Figure 22. Lateral aspects of the skulls of, (**a**) *Coronella girondica* from Montpellier, France (BMNH 1964.1117), showing the undifferentiated maxillary and mandibular teeth (compare with**, b** and **c**); (**b**) *Macroprotodon cucullatus textilis* from Sidi Djillali, Algeria (IPA uncatalogued); (**c**) *M. mauritanicus,* Batna, Algeria (BMNH 1920.1.20.1525). **d**, dentary; **ect**, ectopterygoid; **eoc**, exoccipital; **f**, frontal; **f.op**, optic fenestra; **f.ov**, fenestra ovalis; **fr.st**, frontal step; **p**, parietal; **pal**, palatine; **pmx**, premaxilla; **po**, postorbital; **pro**, prootic; **pty**, prerygoid; **psph**, parasphenoid; **q**, quadrate; **ra.p**, retroarticular process; **stp**, stapes; **tg**, trabecular groove; **smx**, septomaxilla; **st**, supratemporal; V_2 & V_3 foramina for the maxillary and mandibular branches of the trigeminal nerve. Scale in millimetres.

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Species	M. b. ibericus	M. abubakeri	M. mauritanicus	M. c. textilis	M. cucullatus
Provenance	SPAIN+N. E. MOROCCO	N. W. ALGERIA	N. E. ALGERIA	PRESAHARAN ALGERIA	LIBYA-EGYPT
Maxillary teeth	6+**4**+II	6+**4**+II	6+**3**+II	6+**4**+II (6+5+II)	(6+6+II)6+**5**+II (6+4+II)
Diastema	++++(+++)	++++	++++	++ (+++)	++
Maxilla/premaxilla contact	++++ (n=1)	-	++++ (n=1)	+	+
Maxilla/prefrontal contact	+++ (n=1)	-	++++ (n=1)	++	++
Trabecular groove	-	-	very narrow (n=1)	broad (n=1)	narrowing to broad (n=1)
Lacrimal foramen opening to orbit	-	-	abrupt (n=1)	gradual (n=1)	gradual (n=1)

Table 4. Certain cranial characters in *Macroprotodon* spp. Symbols as in Table I.
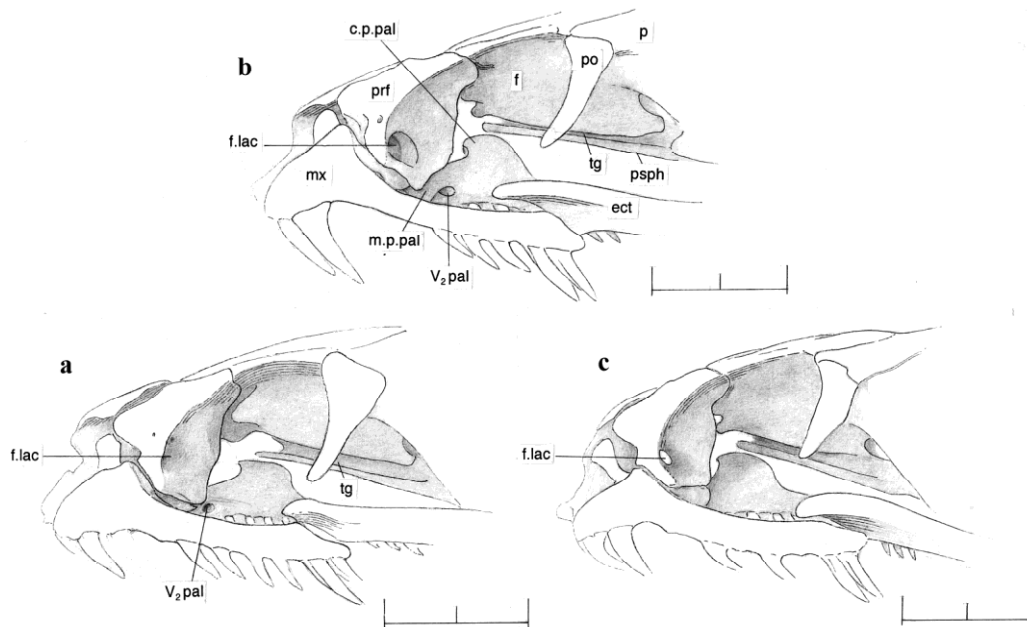
Figure 23. Orbits of *Macroprotodon*, viewed slightly obliquely. (**a**) *M. cucullarus textilis* (IPA uncatalogued), Sidi Djillali; (**b**) *M. mauritanicus* Batna (BMNH 1920.1.20.1525); (**c**) *M. cucullatus cucullatus* Maryut, Alexandria (BMNH 1903.6.18.16). **c.p.pal**, choanal process of the palatine; **ect**, ectoptertgoid; **f**, frontal; **f.lac**, lachrymal foramen; **m.p.pal**, maxillary process of the palatine; **mx**, maxilla; **n**, nasal; **p**, parietal; **prf**, prefrontal; **psph**, parasphenoid; **tg**, trabecular groove; **V$_2$pal**, palatine foramen for the maxillary branch of the trigeminal nerve.

piercing the hard scales of skinks (*Chalcides* spp.) upon which *M. mauritanicus* largely feeds (SURA, 1983). The parietal crests taper to a condition approaching a median ridge (Figure 21, b- albeit at the suture between the parietal and the supraoccipital) as opposed to the widely truncated state (Figure 21, a and c). The lachrymal foramen has the shape of a low tunnel whose vaults commence at right angles to the surface of the orbital wall of the prefrontal (Figure 21, b), as opposed to a more gradual entry

(Figure 21, a and c). The trabecular grooves are exceptionally narrow and the frontal step of the parasphenoid is very low (Figures 22, b & 23, b).

REMARKS ON THE BIOGEOGRAPHY. In contrast to the DNA profiles, *Macroprotodon cucullatus textilis* morphologically behaves as a good species. No intergradation of character has neen found between *M. cucullatus* cf. *textilis* and *M. mauritanicus* where they abut at Biskra; nor between the former and *Macroprotodon abubakeri* where they geographically approach each other in the region of Guelt es-Stel-Ksar Chellalah regions respectively. The "*courbe*" of x=150, where it parallels the Oued Chélif, neatly separates *M. abubakeri* (Ksar Chellala; 5 specimens) from *M. c. textilis* (Guelt es Stel; one specimen). Most of the *M. cucullatus textilis* material examined originated in, or south of the Xerothermomediterranean band, in Alfa steppe (*Stipa tenacissima*), which appears to be its natural habitat.

The remaining territories north of the belt (x=150-200) east of Algiers to the Golfe de Gabès are inhabited by *M. mauritanicus*, which does not appear to enter the steppe. It may, however enter the steppe in the cooler areas around Aïn Beïder (x=100) and Tébessa (x=150) (Map, Figure 24). The regions to the west of the meridian of Algiers below 1,000 metres to the lower Moulouya valley in Morocco are inhabited by *M. aboubakeri* (WADE, 2001), which while occupying variable habitats does not appear to extend southwards beyond the forest belt in the west of Algeria (Map, Figure 25). The formerly forested locality near Ksar Chellala (Atlas des Colonies françaises, Carte Nº V) may represent an isolated population of *M. abubakeri* in the steppe.

The ecology supports the distribution pattern of the three species of *Macroprotodon* as presented by WADE (2001). *M. c. textilis* as a species is a morphologically distinct from the parapatric *M. abubakeri* and *M. mauritanicus*, and inhabits the steppes.

Genus *Hemorrhois*. The Algerian (*H. algirus*) and the horseshoe (*H. hippocrepis*) whip snakes have been long recognized as distinct species. In general appearance the the former more slender, with less distinct markings. However, both species are morphologically more variable than the figures of JAN & SORDELLI, 1876 would imply. The characters by which they may be recognized are not always reliable, especially in the areas of abutment. The characters which define them, in at least the greater part of their range, are clear-cut and are summarized in Table 5, and see Figure 26, a & b; 34, a. & b.).
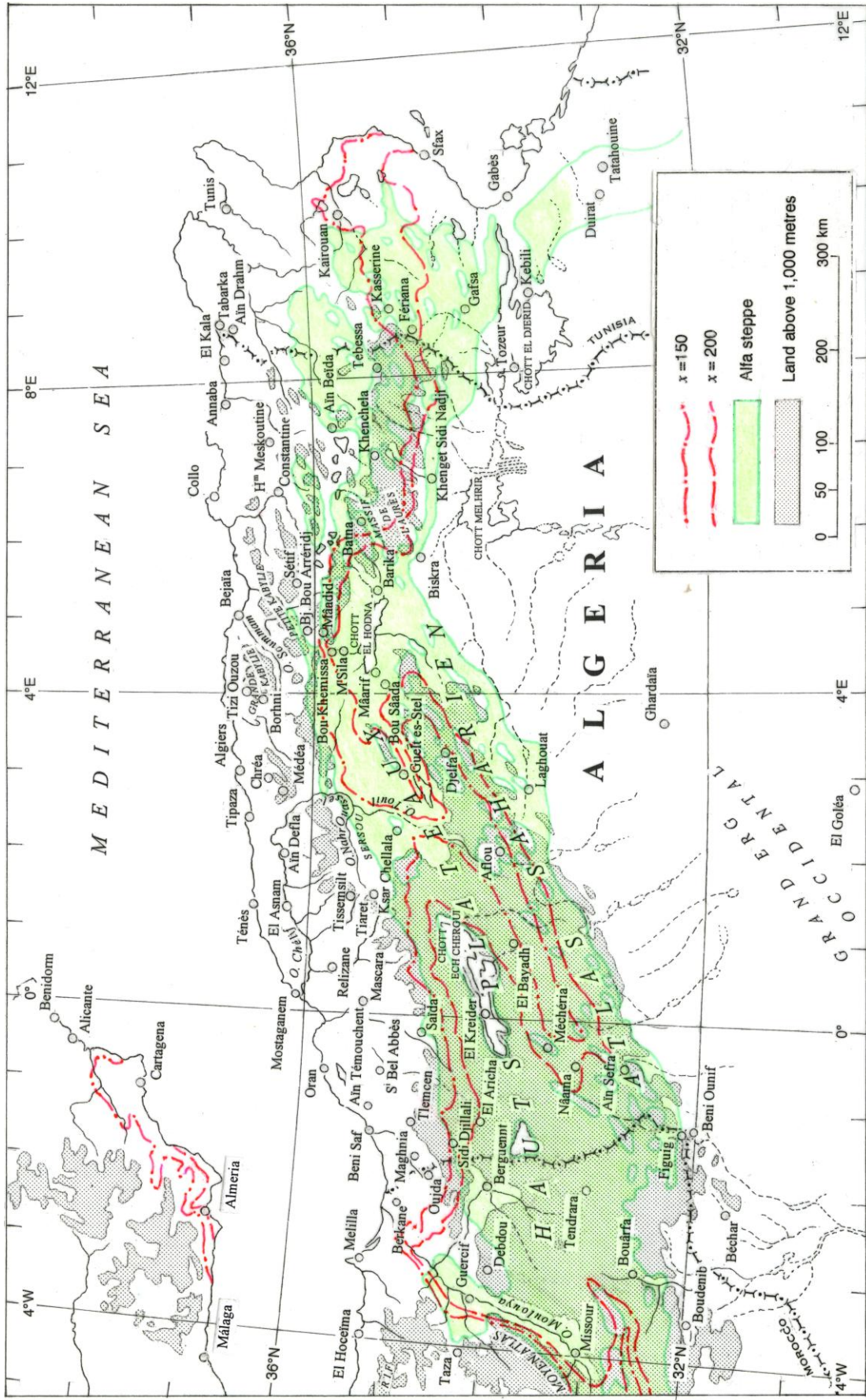
Figure 24. Map of northern Algeria, showing the alfa steppe in relation to the Xerothermomediterranean belt and land at, and above, 1,000 metres altitude.

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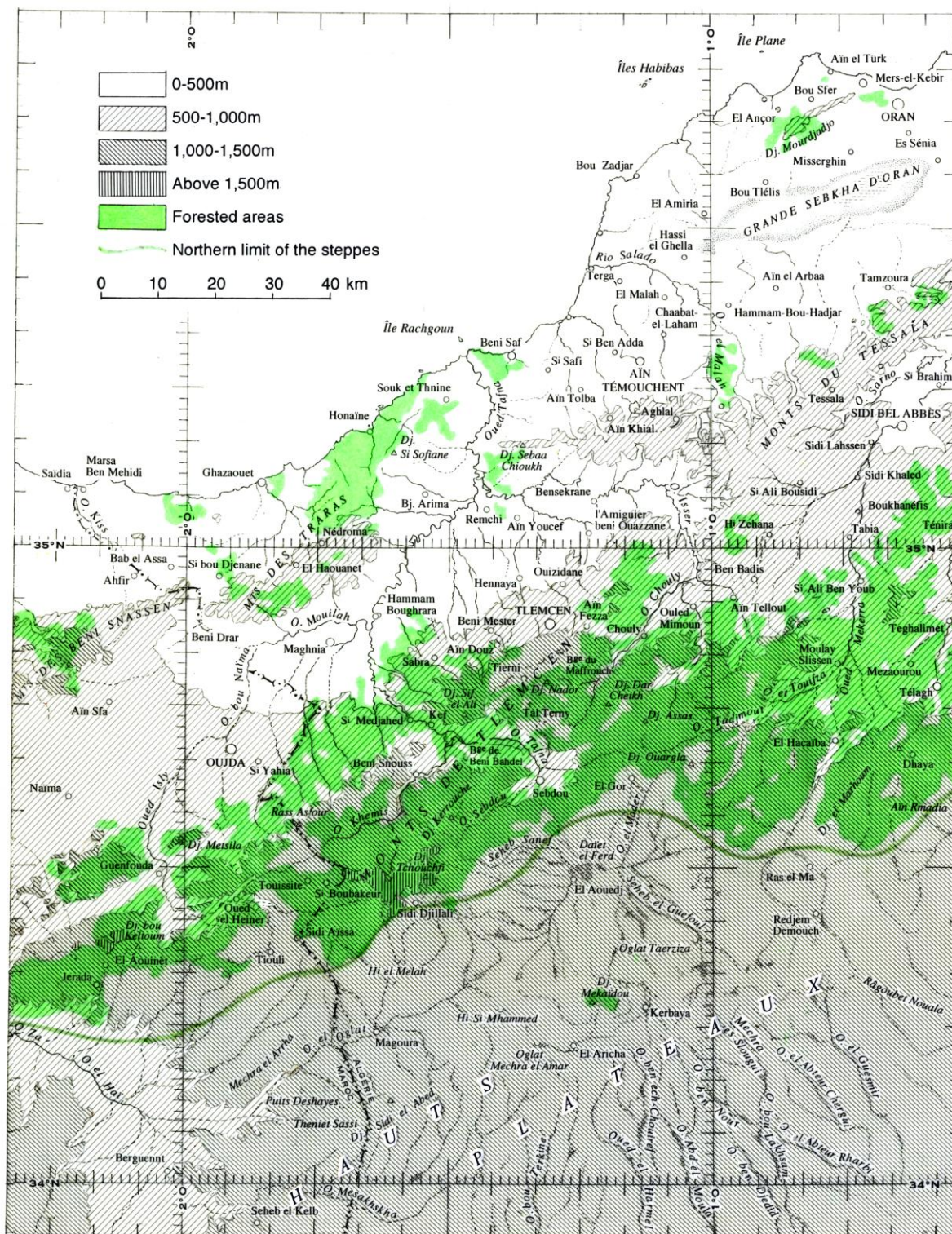
Figure 25. Map of northwestern Algeria. The administrative districts (wilayas) of Tlemcen and Aïn Témouchent showing principal altitudes, forested areas and the northern limit of the steppes.

Species	*H. hippocrepis*	*H. algirus* cf *algirus*	*H. algirus algirus*
Provenance	MEDITERRANEAN ALGERIA	MÂARIF, ALGERIA	ALGERIA (EXCL. OF WEST)
Main head marking	"Ɛ" or "horseshoe" shaped	greyish or black, without distinct "horseshoe" mark	greyish or black, without distinct "horseshoe" mark
Dorsal body markings	more or less as long as wide, close together (Fig. 34 a)	Wider than long, lozenge-shaped, separated by $1-1^1/_2$ scales	considerably wider than long, separated by 2 scales or more (Fig 34. b)
Subocular scales	complete, excluding labials from contact with eyes	complete, excluding labials from contact with eyes	series incomplete, one supralabial contacts eye*
v 50 to v at mid body	(25) 27-29	Fluctuating, 25 26 27 ceasing at v 111 thence to 25**	(23) 25

Table 5. Diagnostic characters of the species of *Hemorrhois* in Algeria exclusive of the west. (*the suborbital series complete in two specimens from Biskra; **23 in two examples from Libya, SCHÄTTI, 1986).

Hemorrhois algirus. **Algerian whipsnake.** *H. algirus* in the west of its range (western Algerian Sahara, Sahara Occidental and extreme north western Mauritania) has the lowest scale counts (23, occasionally 25; SCHÄTTI, 1986) and the "Ɛ" or "horseshoe" head marking, in varying degrees is manifest in all individuals (considered a different race, *H. algirus intermedius*, by WERNER, 1929; GENIEZ et al., 2004), specimens from the larger part of Saharan Algeria and Tunisia the head markings are much the same, i.e. grey or black lacking the Ɛ- mark (Figure 26, 2).

A specimen from Mâarif (south of M'Sila, Algeria) resembled "typical" *H. algirus algirus* in coloration but differed in several respects: (1) the dorsal scale counts fluctuated from 25-26-27 up to the 111th ventral, just short of mid-point along the body, whence they stabilised at 25, whereas in other specimens seen the higher counts cease before the 50th ventral. (2) the subocular scales exclude the labial shields from the eyes (this condition may be found in the occasional individual of *H. a. algirus*). (3) the the dorsal spots are lozenge shaped, as opposed to the bars, and are closer to each other ($1-1^1/_2$ scales apart).

This combination of features suggests some approach to *H. hippocrepis*, or intermediacy between it and H. algirus The present writer assigned the specimen to *H. a. algirus* largely on "general appearance" and the lack of a "horseshoe" head marking. WERNER (1894:75) recorded a similarly patterned "uebergangsform" (=transitional form) from Biskra: it possessed "23 rows at mid body" and one labial shield in contact with the eye.

BONS (1967) in his map (Fig. 14) shows a locality record for "spécimens de transition". The locality is was not identified, but would appear to be between Barika and Biskra, lying some 100 kilometres east of Mâarif along the northern edge of the Arid region. Similar specimens could well be collected from these transitional areas.

The terrain around Mâarif was formerly part of a vast lake of which the Chott El Hodna now remains. El Mâarif is only 53 kilometres south of Bou Khemissa, the most southerly record of *H. hippocrepis* in the wilaya.

Whether more specimens manifesting the divergent features of the Mâarif specimen are to be found elsewhere, along the northern edge of the will be determined by further collecting.
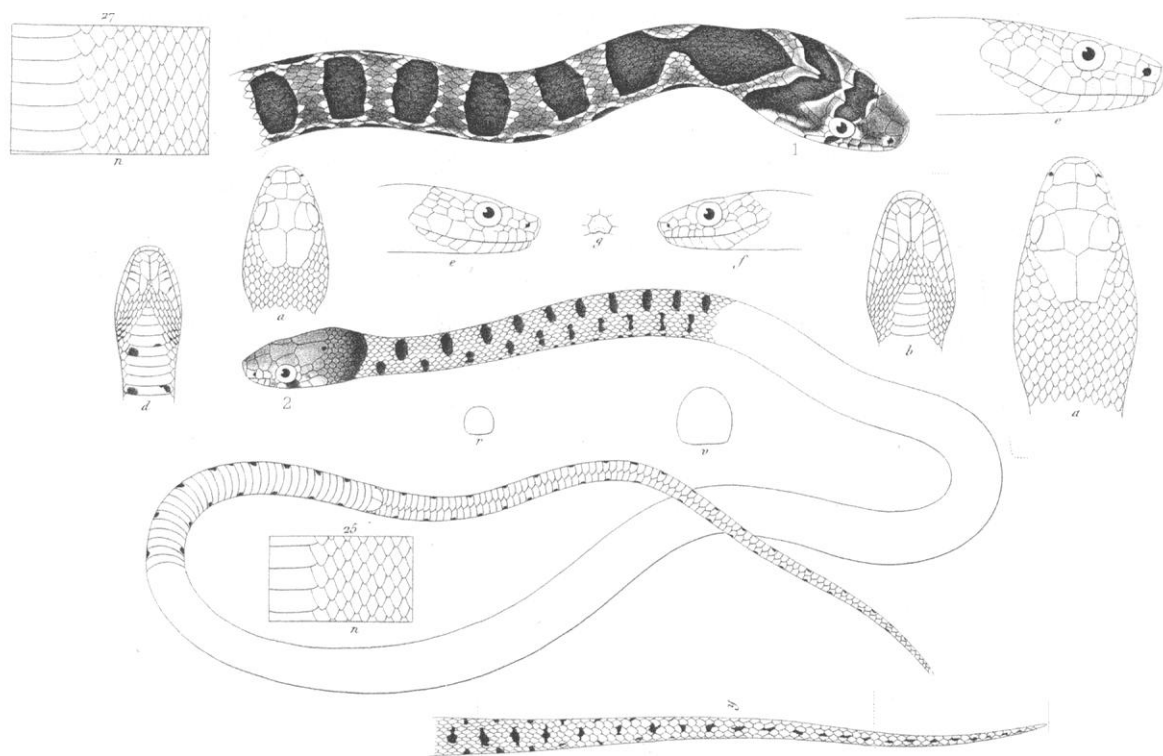
Figure 26. *Hemorrhois* spp**.** Line engravings from JAN & SORDELLI (1876). 48ᵉ livraison, extracted frpm Pl. IV, (slightly rearranged). Fig 1, a and e, *Periops* [=*Hemorrhois*] *hippocrepis* from Algeria; 2, a, b, e and f, *Periops algira* [=*Hemorrhois*] *algirus* from "Sphax d'Algérie" [=Sfax, Tunisia].

Hemorrhois hippocrepis. **Horseshoe whipsnake.** CARRANZA et al. (2006) genetically differentiated the Tunisian sample of the horseshoe whipsnake (*H. hippocrepis*) from those of elsewhere in North Africa and Iberia and minimal differences within the two latter landmasses. In North Africa there were morphological differences. Scale row reductions from specimens from the region of Tlemcen (N.W. Algeria) the more irregular compared with those from the regions of Algiers and M'Sila (present writer, personal observation). In other morphological characters, particularly pattern, there is also considerable variability.

REMARKS ON THE GEOGRAPHY. The distribution of *Hemorrhois hippocrepis* approximates that of *Macroprotodon abubakeri* and *M. mauritanicus*. It penetrates the xerothermo-mediterranean region and the present writer has recorded it from Sidi Djillali (x=150), El Aricha (x=185), Djebel Mâadid

(M'Sila): it has been collected from the same terrain (degraded alfa-steppe) as *Macroprotodon cucullatus textilis*. *H. hippocrepis* has been recorded from the steppic areas, Méchéria (DOUMERGUE, 1901), Sidi Djillali and Bou Khemissa (present writer, personal observation.).

Whilst there is no evidence of intergradation in the Algerian species of *Macroprotodon* in the areas where they abut (WADE, 2001), in similar areas of transition *Hemorrhois algirus* appears to acquire some of the morphological features of *H. hippocrepis* (see above, Table 4). The recorded localites of such specimens are, the Northwestern Sahara (Aïn Sefra), the M'Sila-Barika region ("spécimens de transition", BONS, 1967), Mâarif (present writer, personal observation) and Biskra (WERNER, 1894).

Genus *Malpolon*. The Montpellier snake (*Malpolon monspessulanus*) is primarily a Mediterranean species comprizing four subspecies of which the ranges *M. m. monspessulanus* (Hermann 1804*) and M. m. insignitus* (Geoffroy 1827) meet in Algeria. The other two forms, *M. m. saharatlanticus* Geniez et al. and *M. m. fuscus* (Fleischmann) occur in SW Morocco-Sahara Occidental and E. Europe-W. Caspian region respectively, have been dealt with by GENIEZ et al. (2006) and CARRANZA et al. (2006). After the publications by SZYNDLAR (1988) and DE HAAN (1999) the genus in Europe has been the subject of renewed investigation (GENIEZ et al., 2006; CARRANZA et al., 2006).

Largely as a result of the work of DE HAAN (1984) and (GENIEZ et al (2006) the external diagnostic characters serve to identify the adult forms of *M. monspessulanus*. The authors restricted their analysis to adult males. There is as yet no reliable method of identifying other than some juvenile and subadult specimens. GENIEZ et al (2006) addressed the forms from Morocco and the Western Sahara, and described a new subspecies *Malpolon monspessulanus saharatlanticus*. They considered the Hauts Plateaux form as belonging to the eastern race *M. m. insignitus*. In eastern Morocco there exists a population of the "eastern" form of Montpellier snake (*Malpolon monspessulanus insignitus*) some of whose members were alleged to possess 17 rows of scales (BONS, 1967; BONS & GENIEZ, 1996). The present writer found in a road-kill from El Aouedj (north western Algeria; see map, Figure 25) a varying count of 17 and 19. In another individual from Sidi Djillali, some 35 kilometres to the west, the counts were similar (see below) GENIEZ et al. (2006:66), for the steppic populations from eastern Morocco, affirm that the mid-body count in *M. m. insignitus* was "...19 among all specimens". The possibility that all those 17-rowed specimens may actually possess 19 is lent credence by DOUMERGUE (1901) who cites 4 specimens from Méchéria with counts of 19, 18, 17, 19 respectively. The adult forms (exclusive of *M. m. saharatlanticus*) may be differentiated thus: males of *M. m. monspessulanus* possess a darkening of the post nuchal scales on the anterior part of the body (the dark 'saddle" of GENIEZ et al. (2006) and differentiated lower flank scales (rows 1-4) each with pale spots whereas *M. m. insignitus* of the same sex lack them. Adult females of *M. m. insignitus* may be recognized by the dark markings of the 1st scale row forming a continuous stripe as opposed to *M. m. monspessulanus* in which it is absent (Plate II,).

Subpecies	*Malpolon m. monspessulanus*	*Malpolon m. insignitus*
Dorsal scalation	**19**	**17**, 17/19 or **19**
"Saddle" on neck of ♂♂	present	absent
Flank scale pattern differentiated from upper dorsals in ♂♂	present	absent
1st dorsal row of scales in ♀♀	not differentiated from the other flank scales	dark spots coalescing to form a line
Basioccipital process of basioccipital bone	Smooth, with 2 outer prongs; may have a 3rd, less prominent, in centre	"knobbed", lacking discrete prongs

Table 6. Main characters which differerentiate the subspecies of adult *Malpolon monspessulanus* in Algeria.

GENIEZ et al., (2006) were unsure how far *M. m. monspessulanus* extended into Algeria and identified an adult male specimen from Saïdia (extreme N. E. Morocco, at the frontier with Algeria) as an "intermediate" between the two races. From observations of the present writer on museum and vivarium specimens, it would appear that sexual dimorphism appears only when adulthood is well advanced, at least in Algeria. A large male (BMNH 1920.1.20.607), from "Sersou" (=Plateau du Sersou) Algeria, exhibited the pattern features of *M. m. monspessulanus* clearly. A specimen of *M. m. monspessulanus* from Chréa, 764 mm total length, exhibited an incipient dark saddle and differentiation of scales on the lower flanks. Its identity was confirmed by DNA (CARRANZA et al., 2006), thus the range of *monspessulanus* was extended as far as the meridian of Algiers.

SZYNDLAR (1988) differentiated the two European forms on skull characters the most notable being the basioccipital process on the basioccipital bone. This process was single and "knobbled" in a specimen of *M. m. monspessulanus* from Spain; smooth and bi-pronged *M. m.* "*insignitus*" [=*fuscus*] from Bulgaria (SZYNDLAR op. cit. Fig. 3, 1& 2; and *in litt*.). In Algeria the single-rugose condition was manifest in an adult specimen of *M. m. monspessulanus* from Beïder-Mersa Ben Mehidi (road kill, it was not evident in a young specimen of snout-vent length 385mm from Tal Terny (map, Figure 25). The bi-pronged condition was found in a (not quite) adult road kill of *M. m. insignitus* from near El Kala (map, Figure 24). A smooth tri-pronged basioccipital process was manifest in a skull of a specimen labelled as "*Coelopeltis insignitus*" from "Sersou" (BMNH 1920.1.20.781); the median projection is smaller than the outer ones. As the preserved specimen (BMNH 1920.1.20.607) from that locality (see above) was incontrovertibly a *M. m. monspessulanus* exhibiting the characteristic male patterns, two subspecies are involved; however, the basioccipital process seems somewhat variable and could be of reduced value as a taxonomic character. The Sersou Plateau (map, Figure 24) lying on the northern limit of the steppe, may form part of the line of demarcation between *M. m. monspessulanus* and *M. m. insignitus*.

Plate II. (**upper**) Adult female *Malpolon monspessulanus monspessulanus* from N. W. Algeria. (**lower**) Adult female *Malpolon monspessulanus insignitus* from the N. W. Algerian steppe showing the characteristic stripe along the first scale row.

Plate III. *Malpolon monspessulanus insignitus*. Roadkill: subadult female from M'Sila-Bou Sâada road.
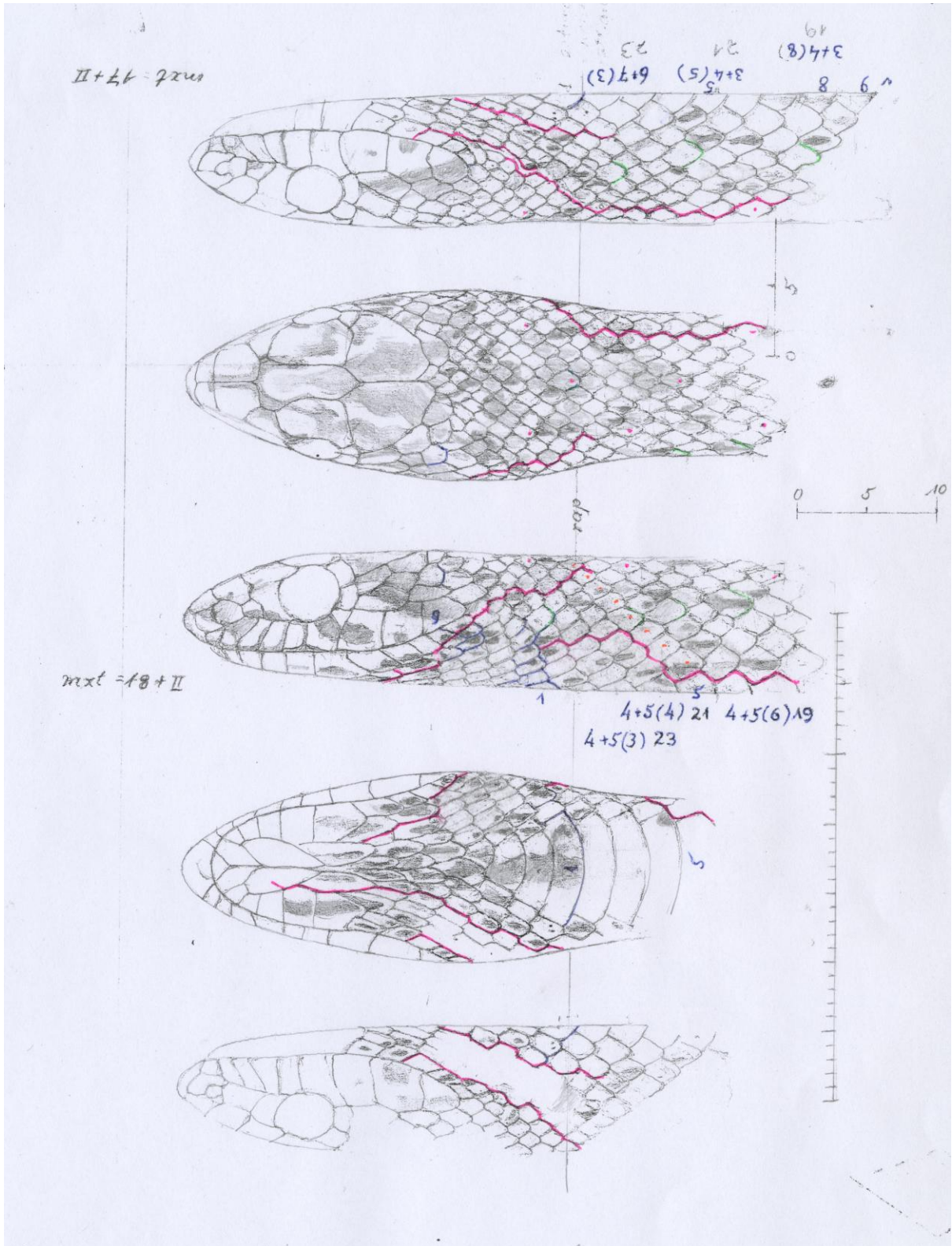
Figure 27. Eastern Montpellier snake (*Malpolon monspessulanus insignitus*), the same specimen (the region of M'Sila) as in Plate III. The head and neck have been reconstructed and mapped out; the positions of the torn areas in magenta. Scale in millimetres.
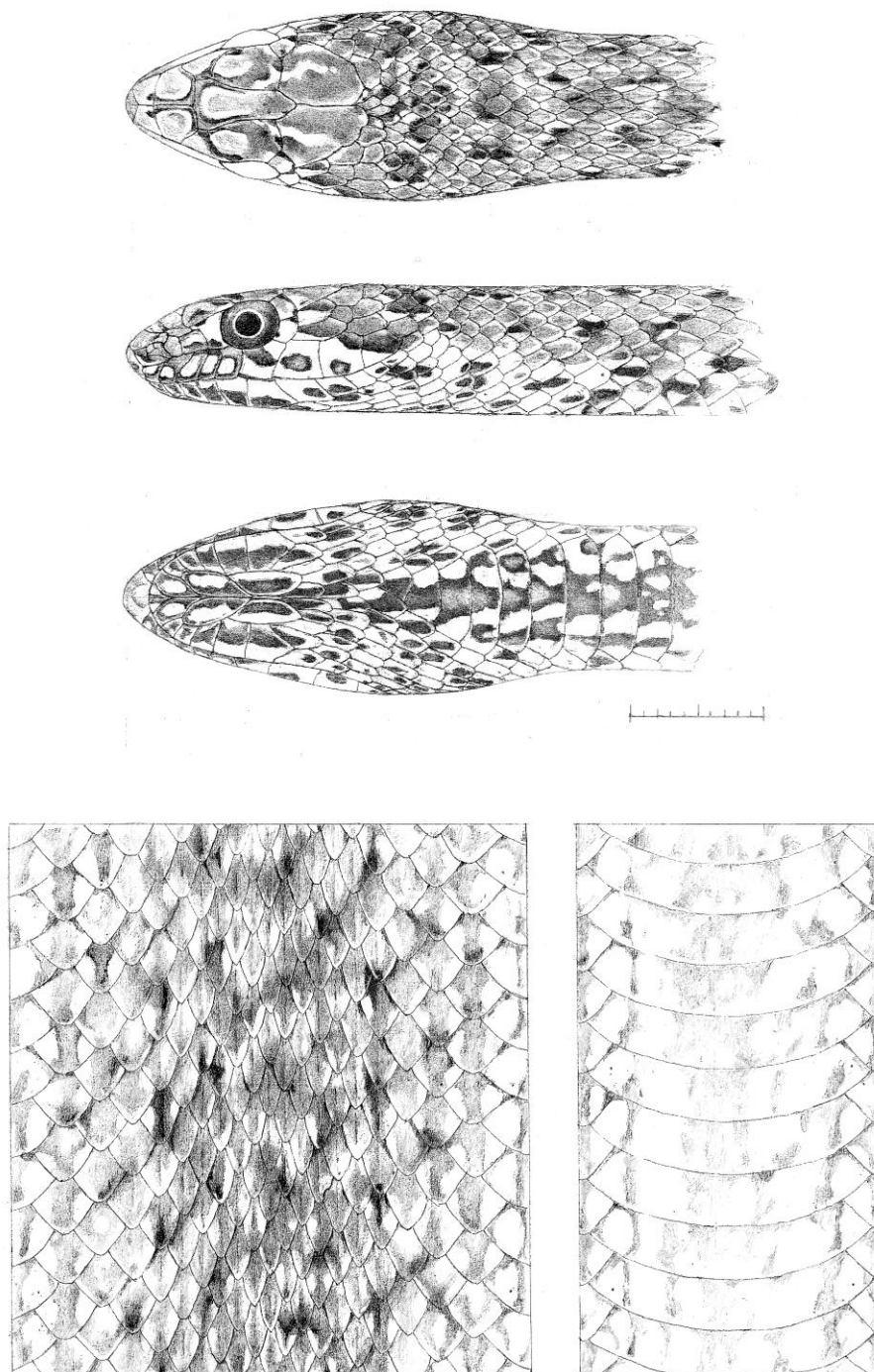
Figure 28. *Malpolon m. insignitus* from the region of M'Sila. Reconstructed from the specimen figured in Plate III. Head and neck, midbody scalation and pattern+belly: note the markings on first scale row have not completely coalesced to form a stripe, see adult female depicted in Plate II , lower figure. Scale in millimetres.

JAN & SORDELLI, 1881, Pl IV, Fig. 23) figure a skull of "*Coelopeltis* [=*Malpolon*] *insignitus*" without source, showing three projections on the basioccipital process, the median projecting very slightly beyond the others. This character, at least in Algeria, may not be relied on without more evidence in the definition of the subspecies. Other characters, such as 5th supralabial-temporal contact and tooth counts, have been of some value but they were equivocal or inconclusive.

INCERTA SEDIS. An adult road kill from El Aouedj (regrettably disgarded) showed the features of a female *M. m. insignitus* (similar to the individual in plate II, lower figure) but CARRANZA et al. (2006) on DNA identified it as *M. m. monspessulanus*. El Aouedj lies on the steppe along the northern margin of the Hauts Plateaux (map, Figure 25) where *M. m. insignitus* would be expected to occur (GENIEZ et al., op. cit.).

GEOGRAPHIC CONSIDERATIONS. The races of the Montpellier snake, excluding extreme western form, *Malpolon monspessulanus saharatlanticus* Geniez et al., *M. m. monspessulanus*, *M. m. insignitus* follow a similar pattern of distribution to that of the false smooth snake, as far as the Massif de l'Aurès (see above, Genus *Macroprotodon*; also WADE, 2001).
The north-western form, *Malpolon m. monspessulanus* shares the regions occupied by the subspecies of *Macroprotodon brevis*. The steppes to the south are inhabited by the eastern form, *M. m. insignitus*. East of the Chott el Hodna the steppe is interrupted and fragmented by the Massif de l'Aurès much of which is forested. Whilst *Macroprotodon cucullatus textilis* is replaced in the Aurès and the regions beyond by *M. mauritanicus*, the range of *Malpolon m. insignitus* is unaffected by the same physiographic changes; *M. m. insignitus* continues to spread northwards and eastwards (Bordj Bou Arréridj, the Aurès mountains, Hammam Meskoutine), and the whole of Tunisia as far south as Duirat, thence eastward to Jordan. *Malpolon m. monspessulanus* probably inhabits the Grande Kabylie whereas *M. m. insignitus* may well extend beyond the Hodna mountains to the Petite Kabylie and the Sersou Plateau. The Oued Nahr Ouassel and the valley of the Soummam (i.e. O. Soummam, O. Sahel and O. Eddous) could be the "line" of demarcation between them.

Genus *Rhagerhis*. The Moila snake or "False Cobra", *Rhagerhis moilensis* (Figure 28, a & 29, a) is a desert species which replaces the Montpellier snake in the areas beyond the Mediterranean region into the Saharan. It extends into the northern Sahel (sensu SCHIFFERS, 1974b), where it meets the superficially similar *cordofanensis-maradiensis* species complex from the southern Sahel, with both members of which *R. moilensis* has been confused (see below).
Rhagerhis moilensis has been congeneric with *Malpolon monspessulanus* for a long time (LALLEMANT, 1867; DOUMERGUE; 1901 [as *Coelopeltis*]; SOCHUREK, 1956 and others [as

Malpolon]). Both species have been coupled at a common node in cladograms by CARANZA et al. (2004), KELLY (2005), KELLY et al. (2008) although very different in general appearance (compare Figure 28, a with b and Figure 29, a. with b).

Species	*Malpolon monspessulanus*	*Rhagerhis moilensis*
Snout region viewed from the side	rounded at tip	angled at tip
Snout region viewed from above	Strongly concave	flat
Number of loreals	two	one
Dorsal body scales	slightly oblique, longitudinally furrowed, in 17-19 rows	non oblique, flat, in 17 rows
Maxillary tooth count	14+II to 18+II	10+II to 11+II

Table 7. Principal characters which differentiate *Malpolon monspessulanus* and *Rhagerhis moilensis* in Algeria.

SZYNDLAR (1988:696) suggested that *moilensis* could be removed from the genus *Malpolon* on differences in the braincase "...of which the most important are: suborbital flanges of the parasphenoid shifted far backwards; occipital crest very strong; basioccipital present and well developed [in *M. monspessulanus*]" BRANDSTÄTTER (1995) proposed *Scutophis* as a generic name for *moilensis*, restricting *Malpolon* to *M. monspessulanus*. This proposal was taken up by HASI et al. (1998); GENIEZ et al. (2004) and BRITO et al. (2008:27). BROADLEY, in litt. (2004) questioned the use of the name *Scutophis* largely due to an absence of a formal diagnosis. The available name *Rhagerhis* of PETERS, 1862 (HUGHES & WADE, in preparation) is used here.

RHAGERHIS MOILENSIS COMPARED WITH THE *R. MARADIENSIS-CORDOFANENSIS* ASSEMBLAGE. *R. moilensis* has been included on two occasions in the genus of beaked snakes, genus *Rhamphiophis* (see below).

Species	*Rhagerhis moilensis*	*Rhagerhis maradiensis/cordofanensis*
Posterior head and subocular markings	present	absent
Nasal shield	upper and lower margins not parallel	upper and lower margins parallel
Dorsal body scales	non oblique, exposed margins rounded	slightly oblique, rhomboid, obtusely pointed
Hemipenis	long (8 subcaudals)	short (3 subcaudals, (*n*=1)

Table 8. Summary of characters which differerentiate *Rhagerhis moilensis* and *Rhagerhis maradiensis/ cordofanensis*.

ANGEL (1923) described a new species of snake from southern Algeria on a single, but extensively damaged spirit-faded specimen, MNHN 1922.237, which he assigned to the "beaked" snakes, and

named it *Rhamphiophis septentrionalis*. He later synonymized it with *Malpolon* (=*Rhagerhis*) *moilensis*. CHIRIO & INEICH (1991) described a new 'beaked' snake *Rhamphiophis maradiensis* from Maradi, a town on the border between Niger and Nigeria in W. Africa. TRAPE & MANÉ (2007) synonymised *Rhamphiophis maradiensis* with "*Malpolon moilensis*". This is supported by the superficial similarity of the head scutellation in the two forms with those characters placing *maradiensis* within the range of variation found in *R. moilensis*, Figure 29, a & b). This assignment would seem plausible, but the absence in the Maradi form of the characteristic head marking of *R. moilensis* and other features of head and body scalation+pattern (see below) which indicate that the validity of *maradiensis* should be upheld.

The head pattern in *R. moilensis* consists of a configuration of dark temporal and post temporal markings, a subocular patch (Figure 29, a) together with the spots an the dorsum of the body, albeit variable in prominence, extending on to the 1st scale row and the ground colour merging with the white lower flanks (Figure 30, a) as opposed to an abrupt transition where the spots do not extend lower than the 3rd scale row (Figure 30, b & c). The former pattern combination in *R. moilensis* is essentially the same throughout its extensive distribution from the Islamic Republic of Mauritania to Iran, see JAN & SORDELLI (1870, vol. 3, 34me livraison), Pl. 1, Fig. 2 'Alger'; GENIEZ et al. (2004:165), Pl. 192 Smara-Laâyoune (Sahara Occidental); TRAPE & MANÉ (2007) Aiyoûn el Atrouss (Mauritania, R.I.); GASPERETTI (1988:252) Mecca (Pl. 11) etc.

Differences in the 'stacking' of the dorsal scales between *R. moilensis* and the holotype of *R. maradiensis*, became apparent as a result of drawing them as 'pelts': Figure 30 shows the differences between the two forms. The ***T*** series at around midbody was virtually 90° in all *R. moilensis* examined whereas it was distinctly 'bowed' at about 75° in *maradiensis*. The individual scales were similarly more rounded along their free margins as opposed to more straight-edged and rhomboid. In *R. moilensis* the body appears slightly depressed whereas in *maradiensis* the body is more cylindrical. *R. moilensis* is notable for adopting a threat posture similar to that adopted by the cobras, i.e. the flattening and expansion of the neck (TRAPE & MANÉ, 2007:116 and numerous authors). CHIRIO & INEICH (1991) in spite of having some degree of familiarity with live specimens, did not report this feature in *maradiensis*: the stance of the live individual in their photograph (p. 227) is more redolent of a *Psammophis*. Pending further study (HUGHES & WADE in preparation), recognition of *maradiensis* as distinct specifically from *R. moilensis* is likely. Similarly, the same course of action would apply to a specimen (BMNH 1940.2.6.1) from Umm Ruaba, Kordofan (Sahelian Sudan) originally labelled "*Malpolon kordofanensis*", currently re-labelled "*Malpolon moilensis*": the "stacking" of its body scales is identical to that in *R. maradiensis* (Figure 30, b and c).

The difference in scale features between *R. moilensis* and *R. maradiensis/cordofanensis* is supported by differences in the size of the hemipenes. For *R. moilensis*, DOMERGUE (1954/55) illustrates the everted organ which would extend a distance of at least 18 ventrals; *R. cordofanensis*, by contrast, has
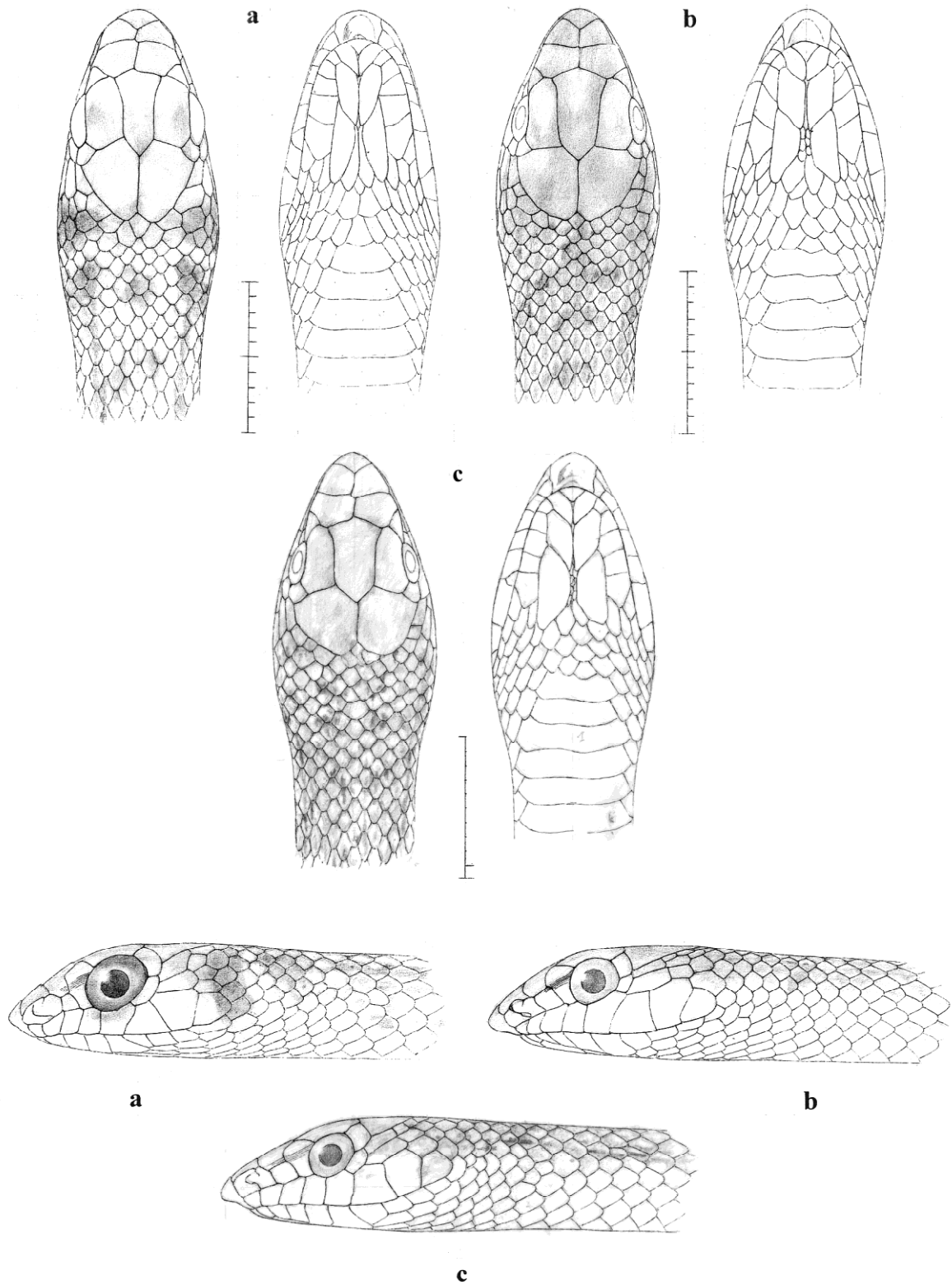
Figure 29. Heads of *Rhagerhis* spp. (**a**) *R. moilensis* (BMNH 1969.2191) from Biskra, Algeria. (**b**) Holotype of *Rhamphiophis maradiensis* Chirio & Ineich (MNHN 1989.2739) from Maradi, Niger. (**c**) *R. cordofanensis* (BMNH 1940.2.6.1) from Umm Ruaba, Kordofan.
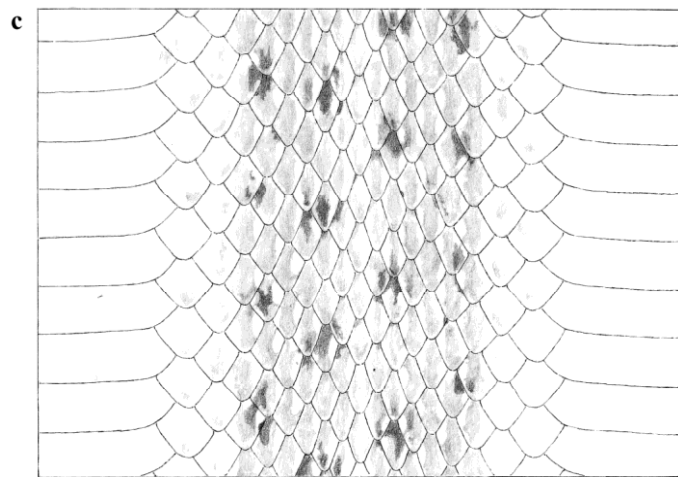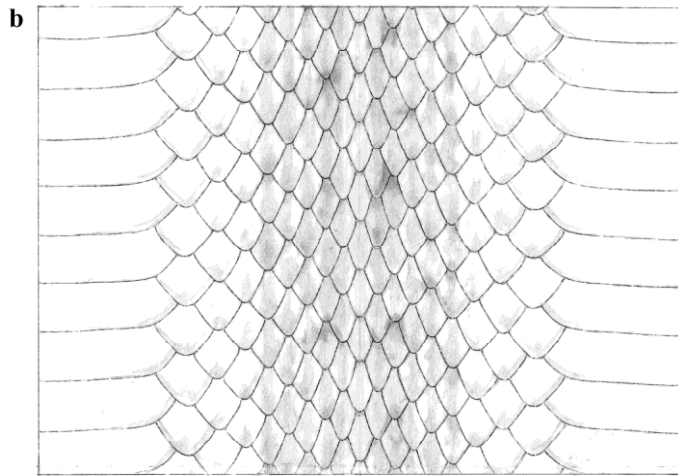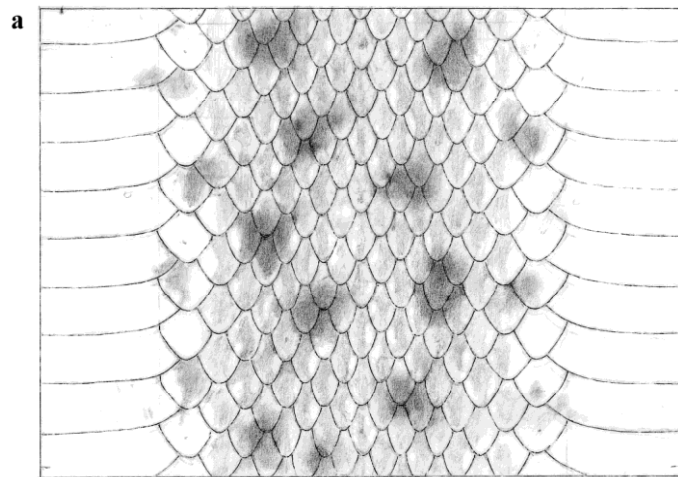
Figure 30. Midbody scalation of: (**a**) *Rhagerhis moilensis*, BMNH 1969.2191. (**b**) *R. maradiensis* MNHN 1989.273. (**c**) *R. cordofanensis* (BMNH 1940.2.6.1).

the everted organ only two or at most three ventrals long: a separate genus may well have to be found for the *maradiensis/cordofanensis* complex.

The Moila snake (*Rhagerhis moilensis*) replaces the Montpellier snake (*Malpolon monspessulanus*) in territories south of the xerothermo-mediterranean band: it does not extend beyond the arid regions of North Africa (DOUMERGUE, 1901:300; SOCHUREK, 1956:85; DAVIDSON, 1964:16; BONS & GENIEZ, 1996:245, and other authors. There has been some confusion as to identity of certain populations of the species in Niger, and *Rhamphiophis maradiensis* Chirio & Ineich (=*Coelopeltis cordofanensis* Werner), as the morphological characters were superficially similar to *Rhagerhis moilensis*, but the real differences were identified during the execution of the drawings of the specimens (Figures 28 & 29). Only seven specimens have been seen (Niger, n=4; Sudan, n=3) but they resemble each other sufficiently as to warrant recognition at species level (see above, and HUGHES & WADE, in preparation).

In Niger, *R. moilensis* extends southwards into the northern, more arid zone of the Sahel. SCHIFFERS (1974) defines this zone as having 100-50mm rainfall. *S. cordofanensis*, by contrast occurs in the southern zone of the Sahel (isohyets of 500-1000mm) in which features of the savanna occur. This climate level in Niger is similar in Sudan, and would include Chad in the range. *R. cordofanensis* would appear to be "sandwiched" between *R moilensis* of the Sahara-northern Sahel and *Rhamphiophis oxyrhynchus* (beaked snake) of the savanna and the tropical regions.

FAMILY VIPERIDAE.

Genus *Cerastes*. These snakes possess obliquely directed serrated scales on the flanks. Those on the dorsum run parallel with each other in many populations (Figure 35, a). A curious feature occuring in other populations is the divergence of the upper dorsal rows (as opposed to those on the flanks) from the long axis of the body obliquely in a backward direction (Figure 35, b); see Appendix III for details.

Cerastes cerastes gasperettii in Arabia was considered a separate race. During the course examining the *Cerastes cerastes* collection in the Natural History Museum (London) and selecting a suitable specimen for illustration (in GASPERETTI, 1988, also see above 3.3.2; 3.6) the present writer had observed that some specimens of *C. c. gasperettii* possessed parallel upper dorsals as in the nominate race from North Africa. WERNER et al. (1991) raised *gasperettii* to full species but assigned these specimens with parallel upper dorsal rows to *C. cerastes* although using other characters.

While the condition of the upper dorsals appear to agree with other states (used by WERNER et al, op. cit.) in the treatment of the Arabian *C. cerastes* and *C. gasperettii*, it remains to be demonstrated whether the same is true for *C. vipera* analysed by JOURIS & FOURMY (1996).

The character state of divergent upper dorsals (Figure 36, b), although not mentioned as such, was that presumably induced KRAMER & SCHNURRENBERGER (1963) "*Die schiefgestellten, scharfgekielten*

Lateralschuppen sind nicht immer klarerkennbaren Reichen. angeornet" [=....*arrangement not always clear*] and JOURIS & FOURMY, (1996)"...*too difficult to reproduce*..." and to discard transverse scale counts when dealing with *Cerastes vipera*.

REMARKS ON THE BIOGEOGRAPHY. The "parallel" state in the upper dorsal scales appears to be the condition in material from the Sahara proper. The only references to the condition of the mid-body scale arrangement are by CHPAKOWSKY & SCHNÉOUR (1953), "Écailles dorsales grandes, carènées. Sur le dos, les arêtes et les écailles forment 9 lignes parallèles...". It would appear from a cursory viewing of available photographs that, in North Africa, the "parallel" condition occurs in populations from the Sahara proper, as shown in individuals from between El Aïoun and Smara, Sahara Occidental, (GENIEZ et al., 2004), the Ténéré near Taghmert, Niger (TRAPE & MANÉ, 2007), the Hamada el Hamra (Libya) (present writer, personal observation) and a specimen from El Goléa (Figure 35, a).

By contrast, the divergent condition seems to prevail in populations on the northern periphery of the Sahara: specimens from Biskra (this work, Figure 35, b); Zaranik, Northern Sinai (BAHA EL DIN, 2006, Fig. 116); Bou Sâada (BMNH 1920.1.20.1185a); Tatahouine, Tunisia (present writer, personal observation). The condition is clearly manifest in the individual from Tripoli shown in the lithograph in BOULENGER, 1891 (Figure 4, 2a). In three specimens from M'Sila (IPA 1.2002.12-13 and -13a) and one from Khnifiss Lagoon, Morocco, GENIEZ et al. 2004:183, Pl. 213) the divergent condition is somewhat less pronounced.

Genus *Echis*. The two putative Algerian/Tunisian species of desert Saw-scaled viper, *E. pyramidum* (Geoffroy) and *E. leucogaster* Roman, are small snakes, extremely agile and irrascible possessing highly toxic venom. They have large eyes and, as in *Cerastes*, possess keeled upper dorsal and serrated lower flank scales (Figure 31). The North African species are acknowledged to be difficult to differentiate (GILLISEN et al., 1994), SCHLEICH et al., 1996) and conventional methods of analysis have not yet been successful. The situation is aggravated by lack of agreement as to their distribution. CHERLIN (1990) recognized *Echis* "*arenicola*" *leucogaster* as inhabiting the Maghreb proper (Morocco, Algeria and Tunisia), the populations of Libya to Egypt were assigned to *E. pyramidum lucidus*: the line of demarcation between the two being approximated to the Tunisia-Libya frontier (CHERLIN, 1990; 217; map, Fig. 37). MAZUCH (2006: map [lacking a number]) extended the range of *E. pyramidum lucidus* further westwards to include the northwestern Algerian (Biskra) population. This scheme was implimented in distribution map of DOBIEY & VOGEL (2007:138) following DAVID & INEICH (1999). The remaining areas (see CHERLIN, 1990) of the distribution of *E. leucogaster* i.e. Morocco, and presumably the Hoggar and Tassili-n-Ajjer, remained unaltered.

GILLISEN et al. (1994) report a case of a bite from a 655mm captive individual, which "has some
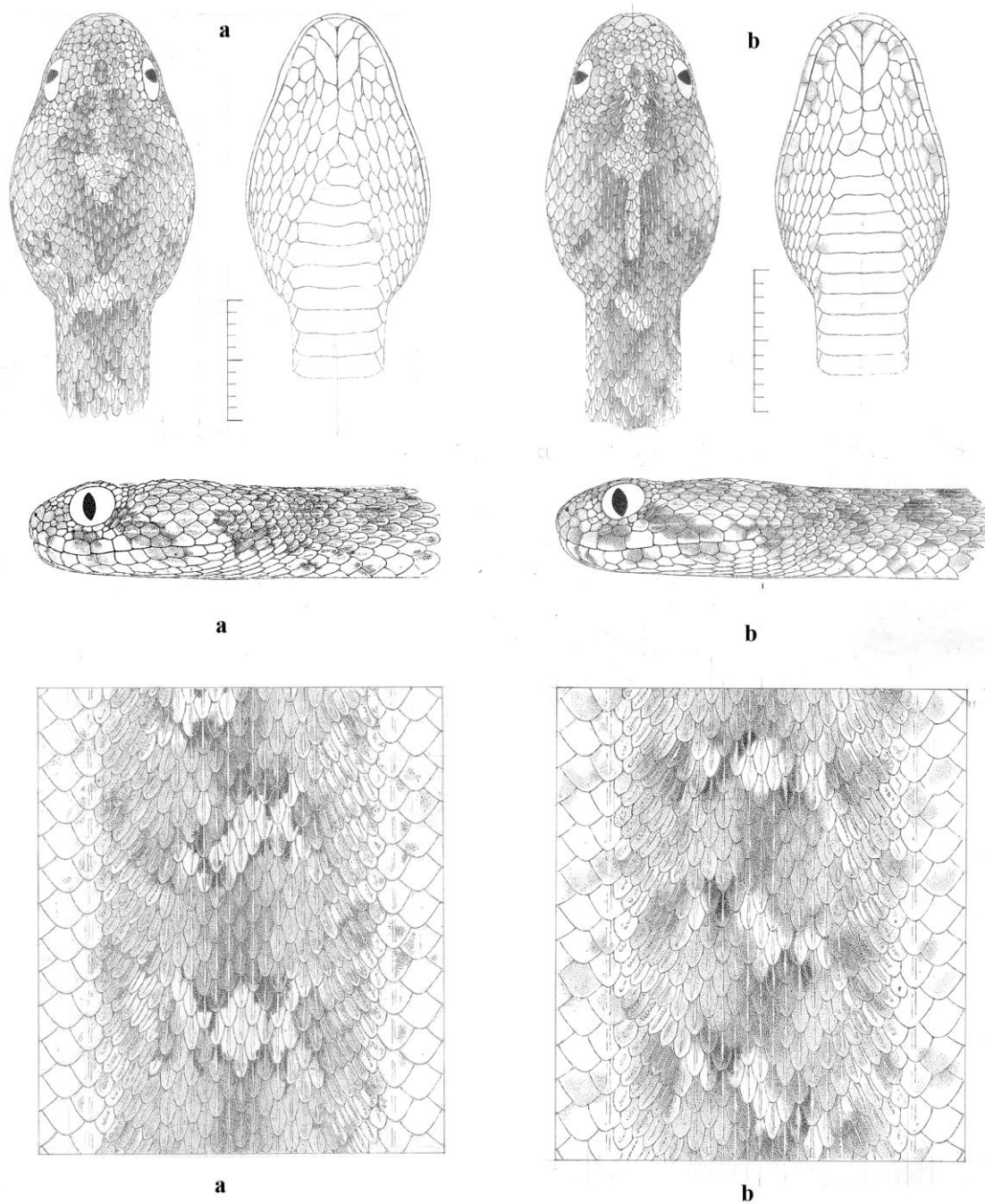
Figure 31. Head pattern and midbody scalation in saw-scaled vipers *Echis arenicola leucogaster*. (**a**) CAS 138680 from Amsel, Hoggar, Algeria. (**b**) IPA 18 (3997), Ghat (Libyan Tassili-n-Ajjer). Scale in millimetres. For amplification on the differences in scalation see Figure 35, c and d.

morphological features of both these species", purportedly from Tunisia and which proved very difficult to treat owing to the the deficiency in the neutralising activity against the venom by the three major commercial anti-*Echis* (North Africa) antivenins. Both species are said "to occur in Tunisia", but CHERLIN (op. cit.) *does not list any Tunisian material examined by him*.

An antivenin is now available against the bite of *E. leucogaster* from Mali and Niger (TRAPE & MANÉ, 2007) and would be expected to be effective against bites from populations from the Hoggar and Tassili-n-Ajjer. The implication of the distribution, as conceived by MAZUCH (2006), if confirmed, whilst clinically satisfactory for the regions inhabited by *E. leucogaster* leaves, not only Tunisia vulnerable, but by virtue of the presence of "*E. pyramidum lucidus*", eastern Algeria, Libya and Egypt also. PEZZANO (1987) in his captive breeding of *Echis pyramidum* does not state the provenance of his material: moreover, he uses the names *E. pyramidum* and *E. carinatus* interchangably. One of three species (sensu lato) could be involved, a bite from which may result in complications described by GILLISEN et al. (1994). There is a lack of precise determination of species boundaries, and at present, adequate genetic and morphological differentiation between the forms.

In view of the temparament of the *Echis* spp., this together with the toxicity of their venom, renders them particularly dangerous. A bite from a captive specimen of unknown provenance (see above) presents a good case for definitive illustrations by which the two species may be recognized both in the field and in the commercial market.

III: CHARACTERS USEFUL IN SNAKE TAXONOMY

Snakes, by virtue of their extreme simplified shape and lack of limbs, have a reduced number of characters available for analysis. UNDERWOOD (1967) stated that; "Clearly any characters in respect of which they vary may be useful in classifying snakes." A character may be useful in a particular genus or species, valueless in another: or its value may be diminished as a result of variability. It is particularly with regard to scalation and pattern that drawing is able to make a significant contribution. This aspect of study has not been undertaken in isolation but was viewed in a broader context. Hence, where appropriate, especially in response to conflicting opinions (eg. those posed by the molecular studies) and where results using traditional procedures were inconclusive, other morphological characters available in skulls and hemipenes have been considered.

HEAD SHIELDS. Head shields (plates or scutes) are important in the classification of snakes. On the dorsal surface they may be "symmetrical" i.e. ten shields; 4 paired, internasals, prefrontals and parietals and two median, a rostral and a frontal (Figure 10) as in most of the colubrids, elapid (cobras kraits etc.) or fragmented, as in the boids (boas and pythons) and most of the vipers.
The condition of number of supralabials and those which contact the parietal in *Macroprotodon* (WADE, 1988; 2001), or the eye in *Hemorrhois*, (Figure 26; Table 5) have been useful in defining populations. The infralabial counts have been used with good results in *Macroprotodon* (BUSACK & MCCOY, 1990; WADE, 2001) and in *Psammophis aegyptius* (MARX, 1958:191).
The condition of contact between the supraocular and prefrontal (i.e. the exclusion of the preocular with the frontal) is stable for *Macroprotodon* spp, *Coronella girondica*, *Lytorhynchus diadema*, *Malpolon monspessulanus* sspp and *Rhagerhis* spp) but labile for *Telescopus tripolitanus* and, notwithstanding GENIEZ et al. (2004, key, p. 214-5) for species in the Western Sahara, also for *Hemorrhois algirus* and *Psammophis schokari*.
HARDY (1972) incorporated counts of gular+preventral scales in his analysis of the Mexican Xenodontine snake genus *Pseudoficimia*. The present writer recorded gulars for the forms of *Malpolon monspessulanus* in drawings for future analysis, but for the present they helped do precisely define throat patterns and were necessary for reconstructions (Figures 27 & 28). The head shields, in varying degrees, have also been found to be useful for defining pattern states (WADE, 1988; 2001).

BODY SCALATION.
Dorsal scales. These are the scales on the body exclusive of those on the belly. Many species are differentiated by transverse counts at midbody. BONS (1960, 1967), BUSACK & MCCOY (1990) in their investigation of *Macroprotodon* differentiated some of the forms on the number of transverse rows at midbody, irrespective of variation in the number within a specimen. WADE (1988, 2001) found midbody counts useful, but with qualification: this character is not always reliable as counts

may increase or decrease, by division or fusion of scales, at varying frequencies along the body. Full scale-row reduction formulae were employed wherever possible (also see WADE, 2001, p. 98, Fig. 6, d & e).

It was found that the state of 21 rows in Iberian peninsular *M. brevis ibericus* not infrequently dropped to 19 in parts of the body in many of the specimens examined. Similarly, with regard to the other forms of *M. brevis* in Morocco, the counts increased in a southerly direction from 21 to 23 to 25 (BONS, 1967) but more often than not fluctuations increased *pari passu*. They reduced to 21 south of Agadir (WADE, unpublished data).
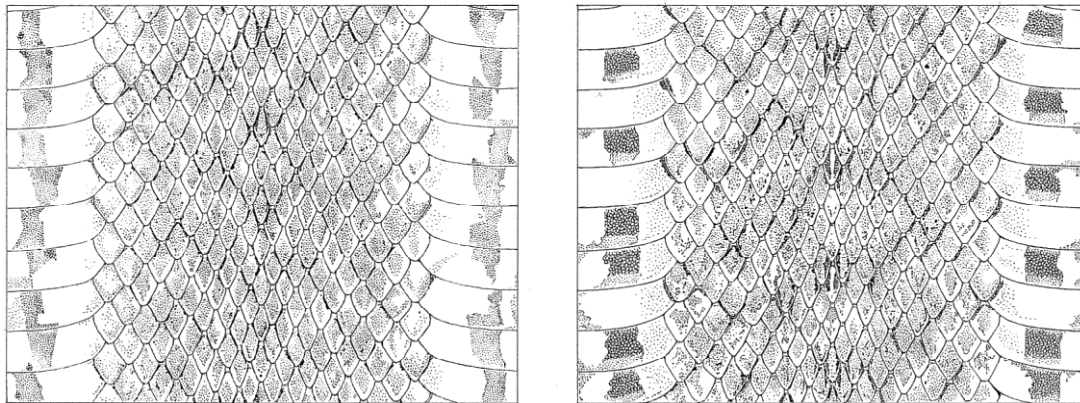
Figure 32. *Macroprotodon brevis* from Oulmès les Thermes (Morocco): (**a**) MCZ 67940 showing the regular arrangement of 23 mid body scales, and (**b**) MCZ 67941 showing asymmetry as a result of fluctuations in the counts on the left side.

With snakes of high transverse scale counts (25 or more), oblique or aberrant scalation scale row, recording reduction may be difficult or not possible. The majority of colubrid snakes in their midbody scale arrangement possess the regular condition, i.e. moderate in transverse counts and not overly obliquely disposed, as in *Naja*, (Figure 34), and consequently present little difficulty in recording. It is when the counts increase that 'irregularities' and attendant problems occur. An example of such a progression may be demonstrated by the body scalation of four closely related Algerian whipsnake-like species of similar dimensions, *Hemorrhois algirus*, *H. hippocrepis*, *Spalerosophis diadema cliffordi* and *S. dolichospilos* (Figure 33). The mid body scales were plotted from a preserved specimen of each species as if they were prepared as pelts to a distance of 16 ventral plates.

The least irregular state is that found in *Hemorrhois algirus* with a count of 25. The character becomes progressively divergent in *H. hippocrepis* with 27(28), *Spalerosophis diadema* with 27-29 to *S. dolichospilus* with 29-33 rows. There were no interruptions either in the longitudinal nor the diagonal rows in the specimen of *H. algirus*; several (involving the vertebral and paravertebral) in *H. hippocrepis* and with *S. diadema* and *S. dolichospilus* virtually at every ventral some split or fusion occured. These differences may be quantified in ratios of dorsals to ventrals. Thus in a stretch of 16 ventrals the ratio may be expressed as 16:16, 18:16, 20:16 and 23:16 for the species *H. algirus*, *H. hippocrepis*, *S. diadema* and *S. dolichospilus* respectively.
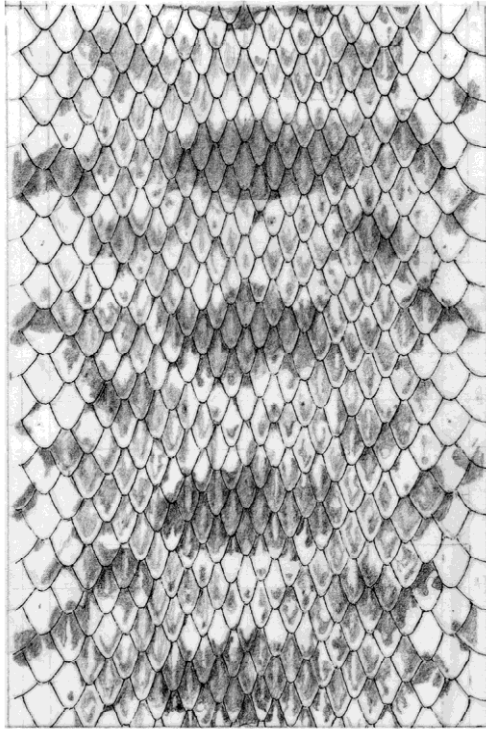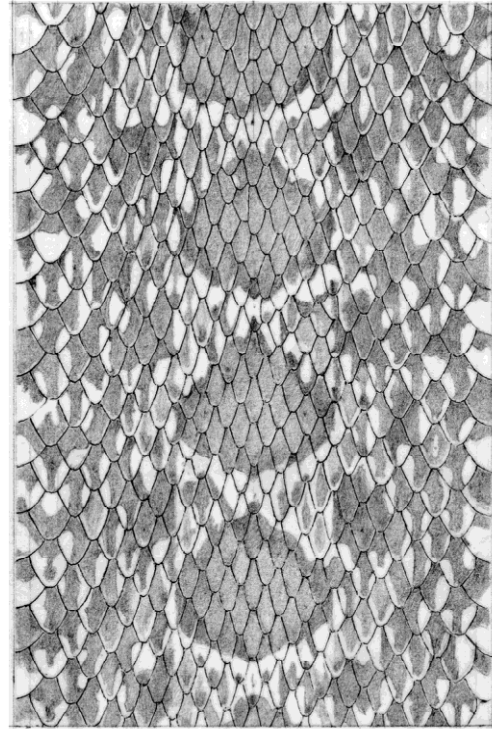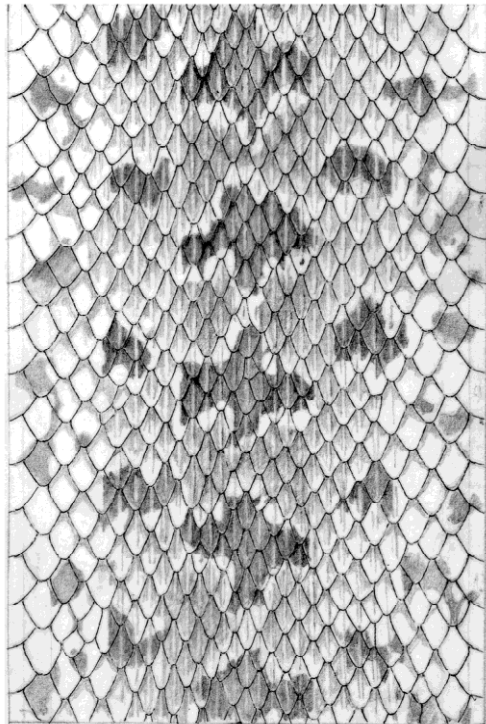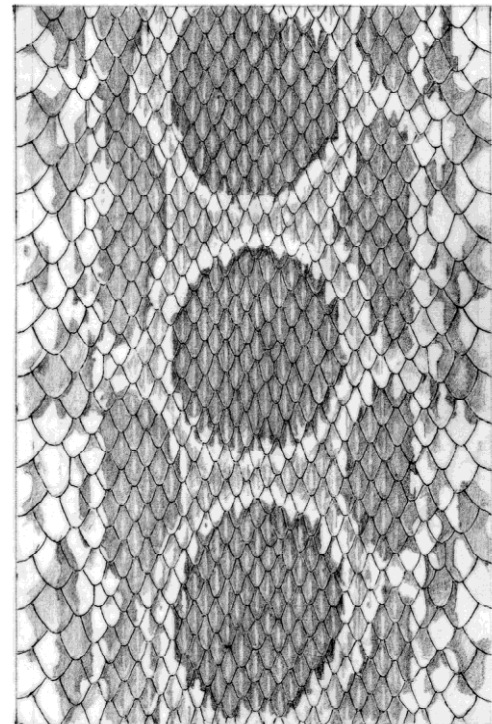
Figure 33. Dorsal scalation at around midbody showing the splittings and fusions of the diagonal scale rows in four closely related Algerian snakes: (**a**) *Hemorrhois algirus* (LKSN) from Khenget Sidi Nadji; (**b**) *H. hippocrepis* (IPA) from Sidi Fredj; (**c**) *Spalerosophis diadema cliffordi* (LKSN) from Khenget Sidi Nadji; (**d**) *S. dolichospilos* (BMNH 1920.1.20.1113) from Biskra. The splittings and fusions increase with the transverse counts influencing the ratios of vertebral scales to the ventral plates but leaving the transverse counts unaffected, except for occasional interruptions.
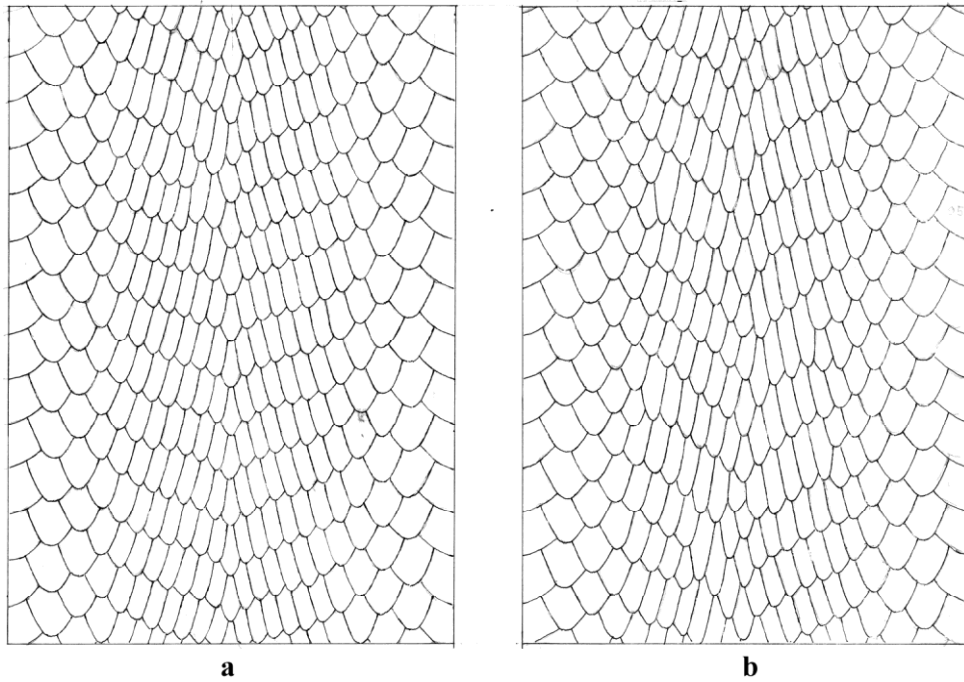
Figure 34. Oblique dorsal scalation in cobras (**a**) *Naja haje* (BMNH 1915.10.29.1) from Biskra, Algeria in which the posteriorly directed diagonal rows are more or less regular; (**b**) *Naja arabicus* (BMNH1985.745) from Dalaghan, Saudi Arabia, in which the rows frequently fuse.

In two species of cobra (*Naja haje* and *N. arabica*) the scale reduction formulae are difficult to express, particularly anteriorly, this being due to the pronounced oblique arrangement of the body scales, particularly on the neck. In contrast to the *Hemorrhois-Spalerosophis* group, the reverse condition occurs where the diagonal rows divide or fuse only in *Naja arabica* from Dalaghan, Saudi Arabia (BMNH 1985.745, Figure 34, b) in which the vertebral scales tend to exceed the ventrals in length. This character state may be variable. Figure 34, a shows the relatively regular condition in a Biskra (Algeria) specimen of *Naja haje* (BMNH 1915.10.29.1).

A different condition in body scalation is to be found in the Saharan dune viper or Avicenna's viper (*Cerastes vipera*). The scales on the dorsum, with longitudinal keels, contrast with those on the flanks, which are obliquely directed and have serrated keels. Two states occur: the "regular" dorsum which exhibits a distinct vertebral and 8 paravertebral rows which run parallel (BMNH 1929.11.9.128, Figure 35, a) from El Goléa and one in which no clear vertebral row is discernible, the "paravertebrals" irregular and oblique (BMNH 1912.11.9.135, Figure 35, b) from Biskra and Figure 4, 2a. from Tripoli. This is an obvious character that shows indications of geographic significance, but which has been disregarded, presumably due to the problems it presents for analysis. Notwithstanding the unequal size of the scales, those on the flanks are regularly disposed up to the 8th row, counted from the belly caudad (along the ***R*** diagonal), as recommended by GANS (1959). It is in the upper dorsals in which the variations occur. In the specimen from El Goléa the upper dorsals comprise 9 parallel rows of scales: the keels likewise are parallel with the long axis. In unequal sized
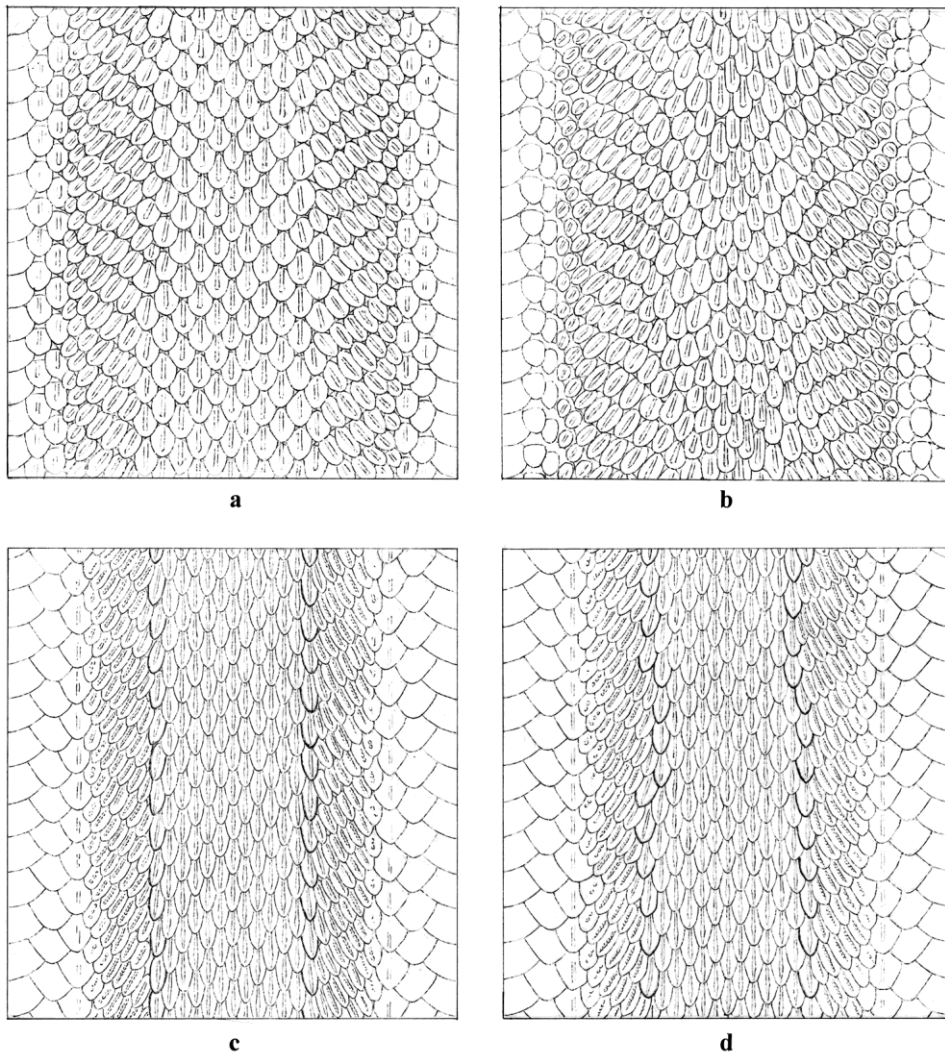
Figure 35. Dorsal scalation at midbody in two species of desert viper. Avicenna's Viper (*Cerastes vipera*): (**a-b**) showing two extremes in the condition of the upper dorsal series in (**a**) BMNH 1912.7.9128 from El Goléa running parallel; (**b**) BMNH 1912.11.9.135 from Biskra in which all the rows are divergent: the vertebral row cannot be determined. Intermediates between these conditions occur. (**c-d**) the Saw-scaled Viper (*Echis arenicola leucogaster*): (**c**) CAS 138680 from Amsel, Hoggar, Algeria; (**d**) IPA 18 (3997) from Ghat (Libyan Tassili-n-Ajjer). The transition from the parallel-keeled upper dorsal midbody scales to those serrated and oblique on the flanks at the 6th paravertebral (counting from, but not including, the vertebral) is less abrupt in **d** than in **c**. The outermost upper dorsal row in contact with the serrated-keeled flank scales is in bold outline.

scales it is inevitable that the rows must fuse or divide, depending on the direction in which the counts are made. To compensate for the discrepancy in the size of the flank and upper dorsal scales, it is on the *C* rows where fusions mainly occur, at about *L* 9.

In the Biskra specimen the *L* rows of the upper dorsal scales, together with their keels, diverge assuming progressive parallelism with the obliquely directed serrated keels of the flank scales, the transition between the two not so clear cut: any parallelism with the long axis exists only for short distances and not for long stretches. The *L* series are regular up to the 8th but fusions may occur more

than once in any direction beyond it. At any arbitrary part on the body selected (the illustrations show distances of 14 ventrals), these fusions or divisions may be noted at the alignment with the requisite ventral scute at which they occur. The illustration may be considered an extreme example of this state in which the *L* rows divide vertebrally and paravertebrally at such frequent intervals as to induce abandonment of this character in analysis. However, intermediate conditions, more easily recorded, exist and the gradations may be noted for their geographical significance.

Ventral scales. The number of ventral scales is one of the characters most used by taxonomists as it approximates the number of somites and may give early indication of species differentiation. Most authors now use the method recommended by DOWLING (1951a). It is the method preferred by the present writer and has provided the most reliable basis for making scale row reductions. TRAPE & MANÉ (2007) used the earlier (traditional) method of including the preventrals as ventrals in the counts "...qu'il est important de pouvoir continuer à utiliser directement la littérature ancienne", but this is at the sacrifice of comparison with the now well established method of DOWLING (1951a). The preventrals may be expressed in lower case Roman numerals and precede the true ventrals (Arabic), thus for example, iii+297 ventrals for 200 gives more information at very little extra cost. Furthermore, in the interest of diminution of the imprecision of this character, particularly in *Telescopus* and the North African psammophiines, the position of the first ventral in relation with the retroarticular process was noted.

DOWLING (op. cit.) proposed the first ventral scute as the point where the body begins: this was found satisfactory for *Macroprotodon* and *Psammophis* but less reliable for *Malpolon*. In the cat snakes (*Telescopus*) the first ventral is situated well in advance of the retroarticular process.

Pattern. Heavy reliance was placed on pattern especially with regard to *Macroprotodon* (WADE, 1988; 2001) and *Psammophis* (HUGHES & WADE, 2002; 2004). It has so far provided the only method of differentiating the races of adult *Malpolon monspessulanus* in Morocco (GENIEZ et al, 2006)

In herpetological literature the use of "templates", i.e. figures showing variability based on single specimens, are frequently resorted to for comparisons of head and body patterns often irrespective of the condition of scalation. LANZA & BRUZZONE (1959) used this procedure for the *Macroprotodon cucullatus* population from Lampedusa and AUFFENBERG & REHMAN (1991) for the *Echis carinatus* complex in Pakistan. Here, except for noted character states, variations or subtleties in head scalation may be overlooked. A notable exception was W. L. Brudon's excellent illustrations of the heads of the Neotropical cat snake genus *Leptodeira* (DUELLMAN, 1958). He did, however in the rendition of mid-body pattern, in common with others, resort to a generalized 'template' similar to that recommended by KESSLER (1996).

Pattern may occur irrespective of how the scales or plates are disposed, but it often follows their shapes or positioning. The two characters have been found to be mutually complementary during the building up of a drawing. Thus body pattern/angle of scale "stacking" combination was found to be of significance in the differentiation of *Rhagerhis* (*Malpolon* auct.) *moilensis* from the Sahelian forms which have been at various times synonymized with it (see above, Genus *Rhagerhis* and Figure 30). The value of scale row reduction as a possible character in *Macroprotodon brevis* was revealed when an interruption in the continuum of the scales was discovered when the pattern in Figure 32, b was being plotted.

HEAD MEASUREMENT. There appears to be no general agreement as to what constitutes the head length in snakes. The length of the mouth appears to be the least labile but as it does not extend as far as the posterior extremity of the braincase it can hardly be used as the head length. Moreover, the region between the mouth and the retroarticular process (allometrically variable in *Macroprotodon*) would be excluded. It is therefore here defined as measured in a *parallel direction* from the rostral to the retroarticular process (WADE, 2001). This is with the realization that for maximum reliability the quadrates should be in their normal position when the mouth is closed.

Head measurements were made parallel to the long axis using modified Vernier callipers in the manner recommended by GOREN & WERNER, 1993 (Figure 36, b). The standard measurement frrom one *point* another (Figure 36, a, *dashed line*) and the parallel from a point to another in alignment to the other   *parallel* to the long axis of the head. There would be differentials (vectors, sensu GOREN & WERNER, 1993) between the values derived from the two methods which could not be eliminated using callipers with prongs of equal length.

There are three good reasons for preference of the parallel over the standard method of measurement:
  * The *standard* method does <u>not</u> reflect the true proportion. Assuming, for example, the *length* of the snout when viewed, or illustrated from the lateral aspect (unless otherwise stated), it would reflect the *parallel* measurement, i.e. parallel to the long axis of the head. The *standard*, or the *point to point* method, would give a higher figure due to a longer diagonal line between the points; it would show the combined *parallell* measurement+the differential or vector.
  * As GOREN & WERNER, (1993) pointed out, the method resulting from the use of a dissection microscope using an ocular micrometer is *parallel* (see also HARDY, 1972); and results, compared with those (rarely qualified, but almost invariably the *point to point* method) from larger animals would be inconsistent as, in effect, two methods would will have been employed.
  * The *parallel* method of measurement is particularly useful in drawing the heads and snouts of broad headed snakes accurately, the imprecise differentials resulting from use of unmodified

instruments (depending on which eye is applied) being eliminated. The parallel method was used for the measurements of the heads of the species of *Pleurodeles* (CARRANZA & WADE, 2004). The term *distance* would be a more appropriate, as opposed to [true] *length* (Figure 36, a *solid line*), STIMSON, 1992, UNDERWOOD, 1992 (personal communication).
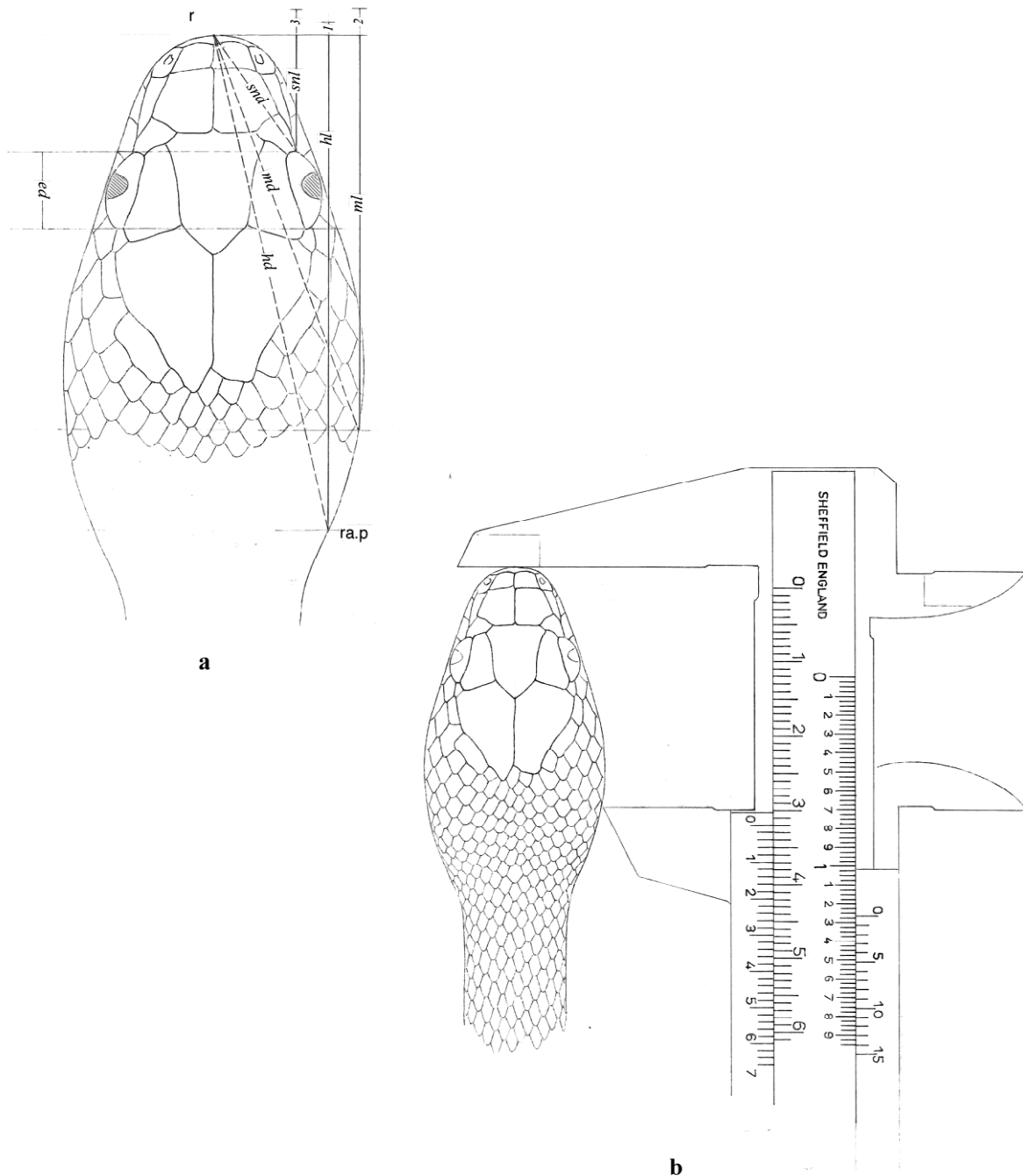
Figure 36. (**a**) Dorsal and lateral aspects of the head of a cat snake (*Telescopus tripolitanus*) showing the main positions from which customary (point to point) and alternative (parallel) measurements are taken. ***hl*** head length; ***hd*** head distance; ***snl*** snout length; ***snd*** snout distance; ***rap*** position of retroarticular process (the position may be determined by palpation). The numbers **1**, **2**, **3** refer to the differentials between *hl-hd*, *ml-md*, *snl-snd* respectively. (**b**) Modified callipers with the proximal 'prong' shortened showing the employment of the parallel method of measurement of the head.

SKULLS. For a long time taxonomists have utilized skulls in analyses. UNDERWOOD (1967) provided a summary of useful cranial characters that may be considered for further research. *Macroprotodon* has relatively few maxillary teeth, 9-11+II (very exceptionally12+II): these 6+3 to 6+5(6) are arranged in two series, 6+3 to 5(6)+II and are separated by a gap or diastema. The numbers of the second series of teeth range from 3 to 5 (exceptionally 6) are is considered significant. Variation in size of the maxilla together with the size of the teeth, together with modifications of the associated premaxilla and prefrontal bones (Figures 20-23), especially when correlated with behaviour, is likewise of taxonomic importance. Conditions of dentition were incorporated in defining the taxa in *Macroprotodon* (WADE, 2001).

The variability in numbers of maxillary teeth was first observed by DUMÉRIL (1854; "6+3 ou 5+2" [6+3 or 5+II]) but no further taxonomic use was made of this character until the present writer recognized its value in differentiating the forms of *Macroprotodon* (WADE, 2001). The usefulness of the length of the diastema between the two series of teeth preceding the fangs was first recognised by the present writer for *Macroprotodon*, but only after 2001). The shortness of the diastema on the visible part of the maxilla in the specimen shown in Figure 14, b, obliged him to rectify his earlier misidentification (the assignment had been tentative, as the scale condition was equivocal and most of the pattern was lost due to spirit-fading): it is here assigned to *M. cucullatus textilis* instead of *M. abubakeri*. The same character was used to identify specimens of *Macroprotodon* in the IPA collection, from El Bayadh and Ksar Chellala (some 200 kilometres between them), as two different species. The pattern of the head and neck was obscured by melanocephalism and the body pattern was affected by damage to the scales due to prolonged immersion in formaldehyde.

The conflict between morphological and molecular profiles in *Macroprotodon* (CARRANZA et al., 2004) motivated investigation into cranial characters. Certain differences of proportion, jaws and elements within the orbits between three forms of *Macroprotodon*, are recognizable (see above, Figures 22 & 23). MAGLIO (1970), however cautions against influences due to differences resulting from "allometric phenomena". He had examined more than 200 skulls for 79 species and subspecies.

In the study of the Montpellier snakes in Algeria cranial were considered (see above, Genus *Malpolon*). Maxillary and mandibular tooth counts can be made on intact specimens, but such data from palatine and pterygoid teeth cannot be extracted without making incisions. SZYNDLAR (1988: 694, Fig. 3, 1 & 2) used features of the braincase, notably on the basioccipital bone (for the insertion of the muscle *transversohypapophyseus*, *pars ventralis* responsible for flexion of the head) to differentiate the species of *Malpolon* (the two European forms of *M. monspessulanus* and *M.* [=*Rhagerhis* in this work] *moilensis*. He figured a single process for *M. m. monspessulanus* and bi-pronged one for *M. m. insignitus*.

Examination of these characters in Algerian specimens was made possible by the acquisition of roadkills. In mitigation of irresversible damage that may resulted from dissection, prior recording the visual data by reconstruction from a roadkill was resorted to. The skull elements/ fragments were exposed, and in most cases the present writer was able to extract the desired data. However, data from road-kills and specimens in the Natural History Museum from Algeria show that the differences between the subspecies, where tooth counts and the condition of the basioccipital process is concerned, are not clear cut.

HEMIPENES. These structures are considered especially as good indicators of relationships by herpetologists (UNDERWOOD, 1967; DOWLING, 1967; BRANCH & WADE, 1976 etc.). UNDERWOOD (op. cit.) stressed the value of everting *both* organs in order to determine symmetry of the spermatic grooves or sulci. Given the importance of hemipenes the following observation is noteworthy. With very few exceptions, a single organ is portrayed, albeit from both the sulcate, i.e. spermatic grooved, and asulcate aspects. DOMERGUE (1955, Pl. XXIII, Fig. 2a, Tunis) depicts a left and SCHÄTTI, 1993, Fig. 25, (MHNG 2415.92 from Agadir, Morocco), a right hemipenis. Making allowance for the different styles of the illustrations, comparison between the two figures showed differences in the size of the spines: those in the Tunisian figure are very small and those from Spain and the Algiers region (one individual from Sidi Fredj) very large. This does not conflict with the DNA differences. However the illustrations also indicated that the sulci appeared to be only *slightly* asymmetrical. Asymmetry in the sulci was one of 'key' characters by which UNDERWOOD (1967) and RASMUSSEN (1985) differentiated the colubrines from the natricines. This character was checked in a pair of hemipenes everted from a specimen from Sidi Fredj: the sulci were found to be *symmetrical*.
The colubrine pattern of asymmetrical sulci (UNDERWOOD, 1967; RASMUSSEN, 1985) was checked for *Macroprotodon cucullatus* and the Horseshoe Whipsnake, *Hemorrhois* (formerly *Coluber*) *hippocrepis*. The unexpected symmetrical condition was found in both species.
Illustrations of hemipenes would be very desirable. They are soft structures which require skill in preparation for drawing (not as yet acquired by the present writer).

GENERAL APPEARANCE. There not infrequently arises situations in which individuals or populations may not readily be evaluated using current taxonomic methods of analysis. Certain snakes, such as the medically important Saw-scaled vipers (see above, Genus *Echis*) prove particularly difficult to identify. Specimens of the genera *Macroprotodon*, *Malpolon*, (excluding *Rhagerhis*) and *Psammophis* are difficult to place their appropriate taxonomic categories. There exist 'realities' which are difficult to qualify and quantify. GREENWOOD (1962 & personal communication) recognized "the nebulous concept of general appearance", upon which affinities, at least initially, may be discerned. Alternatively, lack or neglect of this character, reliance having been placed on more 'conventional' states, may result in misclassification of misidentification. WELLMAN (1969) placed the Central

American xenodontine snake *Crisantophis nevermanni* in *Conophis* when it clearly merited a genus of its own (VILLA, 1969; W. R. BRANCH, personal communication, and the present writer, personal observation). A specimen of *Coluber* [=*Hemorrhois*] *nummifer* from the Aegean island of Kos was misidentified as an *Elaphe quatuorlineata sauromates* (LOTZE, 1974; 1975). The psammophiine "*Rhamphiophis maradiensis*" was synonymised with "*Malpolon*" [=*Rhagerhis*, this work] *moilensis* by TRAPE & MANÉ (2007). However, the two forms were readily separable on "general appearance" and fresh diagnostic characters had been revealed during the process of drawing the specimens (see above, Figure 29).

Agamidae. "Dragon" lizards. A family of Old World lizards which parallels the iguanids of the New World. They are more often than not spinous and crested and possess a wide variation in scalation.

Alfa (or Halfa). Esparto grass (*Stipa tenacissima*), the main constituent grass of the steppe on the Hauts Plateaux: formerly considerably more extensive; now much of it is degraded.

Allometric growth. The growth of body elements at different rates resulting in different proportions, e.g. the eye grows at a slower rate than the head in general and in consequence is larger proportionally in the young than in adults.

Aparallactinae. A subfamily of former colubrid snakes sharing many of the character states of *Atractaspis*, excepting the enlarged movable fangs, and are now placed in the *Atractaspididae*.

Atractaspididae. A family of snakes possessing unique character states, formerly part of, and parallels the colubrids. The type genus, *Atractaspis*, the "mole viper", on account of its possessing movable front fangs, was formerly considered an aberrant viperid.

BMNH. The Natural History Museum (London), formerly the British Museum (Natural History)

Boigini. A tribe, sometimes considered a subfamily, of vertically elliptically-pupilled, largely nocturnal snakes popularly known as cat snakes. The inclusion of *Telescopus tripolitanus* is a matter of dispute.

CAS. California Academy of Sciences, San Francisco.

Caudal. Pertaining to the tail (der. **caudad**, in the direction of the tail).

Cerastes. A genus of heavy-bodied desert vipers comprising 3 species, *C. cerastes*, the horned viper and *C. vipera*, the small, dune-dwelling Avicenna's viper in North Africa and *C. gasperettii* in Arabia. They possess oblique, serrated scales on the flanks which enable them to threaten by stridulation instead of hissing.

Character. A feature in the morphology of an animal.

Character state. The nature or condition of character analysed, eg. If dorsal scalation be the character the term, **state** would apply to whether they be imbricate, juxtaposed, smooth or keeled etc.

Classification. Zoological classification is the ordering of animals into groups (or sets) on the basis of their relationships, that is, of association by contiguity, similarity, or both.

CM. Carnegie Museum of Natural History, Pittsburgh.

Coelopeltis. An earlier name used for snakes of the genus *Malpolon* (q.v.)

Colubridae. A large family of snakes, usually, but not always non-venomous, containing most of the species (der. **colubrid**, **colubrine** etc.).

Cone. Visual cells type[s], A (large single), B (double), C (small single) cones in the retina. Cones lack visual purple. Refringent bodies are present in the mitochondria of the ellipsoid of type A

and the chief, but lacking in the accessory ellipsoid, of type B and also lacking in type C. Adapted for vision in bright light

Coronella. A colubrid genus consisting of the true smooth snakes. One species, *C. girondica* occurs in the Maghreb.

Daboia. A genus of large vipers which include the Atlas Viper (*D. mauritanica*) and the "desert" Viper (*D. deserti*). The former species is widespread in N. Algeria; the presence of the latter has yet to be determined.

Diastema (pl. **diastemata**). Gap or space between series of teeth.

Dorsal [scale]. Any scale along the body of a snake, including the flanks, to differentiate from those on the belly.

Echis. A genus of rather slender, highly agile and dangerous vipers known as saw-scaled or carpet vipers. Two species are represented in Algeria, *E. pyramidum* and *E. arenicola*.

Elapidae. A family of fixed front-fanged venomous snakes which includes cobras, coral snakes etc. The type genus, *Elaps* was found to affine with the *Atractaspididae* rather than the *Elapidae*, thus requiring a new name, *Homoroselaps*.

Electrophoresis. Movement of charged particles in a fluid or gel under the influence of an electric field.

Electrophoretic pattern. Pattern of separation of blood serum, venom etc. in an electric field.

Genus. The family names invariably end in -*idae*. vernacularised as -id. In Algeria snakes are assignable to five **Family.** Formal taxonomic category containing groups of closely related genera , ranking between **order** and families the *Leptotyphlopidae*, *Boidae*, *Colubridae*, *Elapidae* and *Viperidae*.

Fang. Enlarged tooth on the maxilla in some snakes, often serves to conduct venom.

Gekkonidae. Geckos. A family of usually nocturnal, soft bodied lizards more often than not with small granular scales, with or without tubercles. The eyes in most species lack lids and fill the orbital spaces.

Genus (pl.-**genera**, der. -**ic**). Formal taxonomic category comprising a group of species. It ranks below a **family** (and **subfamily**) but higher than **species**. The rank of genus and higher (family, subfamily etc.) invariably begin with a capital letter.

Gular. Throat region or scales thereabouts disposed; bordered by the inframaxillaries, infralabials, preventrals, to the alignment of the 1st ventral. Some authors (eg. HARDY, 1972) include the preventrals. The succeeding flank scales are reckoned as dorsals.

Head scutellation. Nomenclature and arrangement of plate-like scales on the head (Figure 10).

Hemorrhois. A genus, formerly known as *Coluber*, now comprises in Algeria, two species of whip snake: the Algerian Whipsnake *H. algirus*, with two subspecies *H. a. algirus* and *H. a. intermedius*; and the Horseshoe Whipsnake *H. hippocrepis*.

Hemipenis, (pl. **hemipenes,** der. adj. **hemipenial**). The organ of copulation (one on either side, ventrolaterally in the tail in scaled reptiles) situated immediately posterior to the vent. Its value to snake taxonomy rests on the assumption that, irrespective of species variety and

environmental conditions reproduction must take place the method being essentially the same. Reproduction is believed to be least subject to the natural forces of selection in contrast to other features of anatomy which are heavily subject.

Herpetofauna. A oollective term used to describe both amphibians and reptiles.

Herpetology. The branch of zoology which is concerned with the study of amphibians and reptiles.

Holotype. Could be equally called the reference specimen. Designation by the author of a single specimen, or one selected from a series, upon which the description of a species or subspecies is based. The other specimens of the series are termed **paratypes**.

Ichthyology. The branch of zoology which is concerned with the study of fishes.

IPA. Institut Pasteur d'Algérie (Algiers).

Juxtaposed. Scales disposed alongside each other, i.e. not overlapping (c.f. **imbricate**)

Lectotype. A specimen selected by a reviser from a series of specimens from which no single one was designated by the original author of the name. After subsequent selection of a holotype, the remainder of the series are termed **paralectotypes**.

Lacertidae. Family of lizards generally referred to as "Typical lizards" (for want of a more definitive term). They normally lack specialized features such as spines, crests (as in agamids) or highly polished scales (as in skinks) etc.

LKSN. La collection du Lycée du Khanget Sidi Nadji, W. de Biskra.

Loreal. A shield, scute or scale situated between the nasals, preoculars, supralabials and prefrontals, usually separated from contact with the eye (see Figure 1); generally absent in the *Elapidae* and *Atractaspididae*.

Lycognathus. An earlier generic name for *Macroprotodon*.

Lytorhynchus. A genus containing the awl-headed sand snakes. *L. diadema* is the only representative of the genus in North Africa.

Macroprotodon. A genus consisting of the False smooth snakes: three species, *M. cucullatus*, *M. abubakeri* and *M. mauritanicus* occur in Algeria.

Maghreb. The Barbary states, i.e. Morocco, Algeria (exclusive of the "Territoires du sud"), Tunisia and Libya.

Malpolon. A genus originally comprising two species: the Montpellier snake, *M. monspessulanus* and the Moila Snake, "*M." moilensis* (see Genus *Rhagerhis*).

Maxilla. A major tooth bearing bone which is situated on either side of the upper jaw.

Maxillary teeth. An important character major tooth bearing bone which is situated on either side of the upper jaw.

MCZ. Museum of Comparative Zoology, Harvard University, Cambridge, Mass.

Meristic. Numeric characters (or data) which can be counted and computerised, i.e. numbers of scales, teeth etc. (c.f. morphometric).

MHNG. Muséum d'Histoire naturelle, Geneva.

MMBM. Muséum d'Université Mohammed Boudiaf, M'Sila.

MNHN. Muséum National d'Histoire naturelle, Paris.

Morph. A form, usually typical of a species or regional variety.

Morphology. That which is concerned with form and structure i.e. scalation, pattern, proportions and anatomy.

Mucronate. Scales that taper in a point, usually the termination of a keel.

Naja. A genus to which the typical cobras belong. One species, *N. haje*, the Egyptian Cobra, occurs in Algeria.

Nape. The back of the neck: in snakes, refers to the dorsal area just behind the head.

Natricinae. A subfamily of colubrid snakes which includes many of the semiaquatic and aquatic species, including our native grass snake (*Natrix natrix helvetica*).

Natrix. A genus of palaearctic semiaquatic snakes. 2 species, *Natrix natrix astreptophora* and *Natrix maura*, occur in Algeria.

Nuchal. The area at the nape of the neck.

Palato-maxillary arch. Bones of the roof of the mouth which, together, support the palate, comprising the maxilla, palatine, ectopterygoid and pterygoid bones.

Parapatry. Populations of adjacent ranges (c.f. sympatry; allopatry).

Paravertebral. Series/rows of scales running either side of the vertebral or dorsal midline.

Parietal. A paired scute behind the frontal and the supraoculars lying over a median bone of the same name, covering the brain.

Periops. An earlier generic name for *Hemorrhois* and *Spalerosophis*.

Phenotypic plasticity. The ability to morphologically adapt to changes in the environment.

Premaxilla. Median bone situated at the apex of the upper jaw. Lacks teeth in all Algerian snakes.

Psammophiinae. A well-defined subfamily of diurnal rear ranged colubrid snakes, which include the sand snakes (*Psammophis*), Montpellier snakes (*Malpolon*) etc.

Psammophis. A genus of extremely slender, fast moving snakes possessing mild venom. Two, (possibly three) species occur in Algeria; *P. schokari* and *P. aegyptius* (?*P. sibilans*).

Psammophylax. An earlier generic name for *Macroprotodon* and a number of other small colubrid snakes, but now restricted to a group of African psammophiines known as Skaapstekkers.

Race. Ill defined term now supplanted by **subspecies** which is a geographic race.

Refringent body. Granules located in the mitochondria of the ellipsoid retinal photoreceptors of type A and type B cones

Retroarticular process. A projection of the lower jaw at the point of articulation with the quadrate bone. In this work it represents the rear margin of the head length.

Rhamphiophis. A genus of African (exclusive of the Mediterranean region) psammophiine snakes, also known as the beaked snakes.

Rods. Type D visual cells in the retina, possessing visual purple: capable of responding to dim light.

Rostral. Plate or scute situated at the extremity of the snout (der. **rostrad**, in the direction of the snout).

Saddle. A darker strip of black pigment, darkening with age, situated on the anterior quarter of the body in the males of the nominate subspecies of Montpellier snake (*M. m. monspessulanus*).

Sahel. The regional belt across Africa, which is transitionalbetween the Saharan to the north and from the i.e. wooded savanna (Soudanian) to the south. In this work, that of SCHIFFERS (1974) is used: he recognizes a northern zone defined within the isohyets 100-500 mm (Sahelian), and the southern of 500-1000mm (Soudanian).

Scale counts. Longitudinal counts are made from the first ventral scute to the anus; the anal plate not being included. Transverse counts are made in the same manner as for lizards. In certain snakes, e.g. *Cerastes* and *Echis* the method recommended by GANS, 1959, is used. From the 1st ventral counts are made caudad (*R* diagonal), taking care with the strong inclination of some of the specialized scales, until the vertebral series is reached, whereupon the direction is reversed, i.e. along the corresponding *R* diagonal.

Scale rows. In snakes dorsal scale rows are considered in 3 directions and where drawing and reconstruction are concerned, a fourth. *L* (lateral)=the horizontal; *C* (clockwise)=the upper rostrad-lower caudad; *R* (retrograde)=the upper caudad-lower rostrad diagonal rows. The *T* (transverse)=the line made by the tips of the scales of rows 1, 3, 5, 7 etc. at (more or less) right angles to the long axis of the body. The terminology is derived from BREDER (1972) but in this work they express directions of inclinations as opposed to directions for counts of scale rows.

Scale row reduction. A convenient method for expressing transverse counts, the positions at which the reduction (or increases) in number of rows occur and those scales involved. The scale row reduction formula (DOWLING, 1951b) of a specimen of *Macroprotodon abubakeri* (♂, Oran) is shown below. The figures in bold refer to the transverse counts (excluding the ventrals); of scales below the line are on the left, those above the right. The row numbers are counted from alongside the ventral at the back of the head. Those involved in the fusion of rows are denoted by a +, where a row splits by an =; the figure in parentheses refer to the position in vertical alignment at which the reduction occurs.

```
      4+5 (2)      3+4(6)      4+5(147) 3=34(150) 3+4(153)
  23------------ 21 -------------19-------------------------------------------17-------------------------------154
      4+5(3)       3+4(6)                          3+4(153)
```

Thus at the 1st ventral (v) there are **23** scales across the neck, the 4th and 5th row fuse on left at the 2nd ventral (in parenthesis) and a similar occurance on the right at the 2nd ventral reducing the count by two rows down to **21**; the 3rd & 4th row fuse at the 6th ventral on both sides reducing the count to **19**. The count continues uninterrupted until the 147th ventral

where the 4th & 5th fuse, only to split at the 150th and fuse again at the 153rd: this last fusion occurs on the left side along the same ventral, the count now being **17**.

Rhagerhis. A generic name resurrected by HUGHES & WADE (in prep.) to replace *Scutophis* coined by BRANDSTÄTTER (1995) to accommodate the Moila snake (*Malpolon moilensis*).

Spalerosophis. A genus containing the diadem snakes of which 2 species, *S. diadema ciffordi* and *S. dolichospilos* occur in Algeria. The genus is morphologically and genetically very close to *Hemorrhois*.

Species. A formal taxonomic category below a genus consisting of individual animals that can interbreed and possess identifiable characteristics which distinguish them from other closely related groups. The initial letter is, irrespective of whether named after a person or place, is in lower case (der. **specific**, **conspecific** etc.).

Subspecies. Geographic races inhabiting different areas and may intergrade at their zones of contact. As with species, begins with a lower case letter.

Subfamily. A formal or semi-formal taxonomic category below a **family** incorporating a group of closely related **genera**. Subfamily names end in *-inae*, vernacularised as -ine; often used provisionally. Species within the family *Colubridae* would appear to be easily assignable to three subfamilies, the *Natricinae* (watersnakes), *Psammophiinae* (Montpellier and 'sand' snakes) and the *Colubrinae* with its 3 putative "tribes" *Boigini* (cat snakes), *Colubrini* (smooth snakes, whipsnakes and their allies, and presumably, *Macroprotodon*).

Systematics. "...is the scientific study of the kinds and diversity of organisms and of any and all relationships among them" (SIMPSON,1961). The branch of biology that deals with interrelationships between taxa; inextricably linked to taxonomy (q.v.)

Syntypes. A series of specimens upon which the description of a new taxon is based all carrying equal value in the absence of any **holotype** having been designated by the original author.

Taxonomy. The naming and classification of organisms the taxa of which are placed at a given level in a hierarchic classification.

Telescopus. A genus of mainly palaearctic cat snakes. Two species *T. tripolitanus* and *T. obtusus* occur in Algeria.

Tribe. A (often informal) taxonomic category denoting generic groups within a **subfamily** which itself may be imprecisely defined. Tribal names end in *-ini*.

Type [specimen]. An earlier term for **holotype** q.v.

Type genus. The genus upon which the name of the family is based.; e.g. the family *Atractaspididae* takes its name from the genus *Atractaspis*, *Viperidae* from *Vipera*, etc.

USNM. United States National Museum (Smithsonian Institute), Washington.

Ventral. A scale (v), may called a scute or plate as distinct from a dorsal or flank scale, situated on or along the belly.

Vipera. A genus of palaearctic vipers lacking the and stridulating mechanism, and adaptations to desert and sand environments. Five species *sensu lato* occur in the Maghreb.

Viperidae. Vipers: a morphologically well-defined family of dangerously venomous snakes which possess movable front fangs.

Vomer. In snakes, a paired structure which with the septomaxillae form the capsule for the vomero - nasal or Jacobson's Organ, is situated immediately posterior to the premaxilla.

Wilaya. Administrative district in Algeria, analogous to a county in the United Kingdom.

Xerothermic Index (x). A bioclimatic index classing regions in terms of the number of physiologically dry days in the dry season. This system (designed for agriculture) is preferred over the Pluviothermic index as humidity, as well as precipitation and temperatures, are quantified; as such it has a greater influence on the distribution of reptiles.

Xerothermomediterranean Region, i.e. 'hot, dry Mediterranean'. A region defined as lying between the *courbes* [curves] of 150 to 200 physiologically dry days in the dry season, expressed as x=150-200. It forms a transition between the 'true' Mediterranean and the Arid (Saharan).

V: TECHNIQUES USED IN DRAWINGS

The image having been decided, the penultimate pencil drawing after the build up from the successive stages in the reconstruction, is ready for conversion into the final product.

The style/technique of drawing for line reproduction most widely used is the 'stipple'. It has the advantage of uniformity insofar as comparisons of drawings made by different illustrators may be made with minimum mental adjustment. However, the association of line with dots is not really compatible, especially with regard to mechanical pens as these produce marks of unvarying density. This makes the rendering of form difficult. MCDOWELL (1968) however, adopts the style of simulated engraving (presumably executed on scraper board), a technique favoured by medical and veterinary illustrators.

Having decided on the size, the worked out pencil drawing is transferred from the tracing paper to CS 10 (a tough versatile paper which permits corrections applied with a scalpel blade and gives good printed results) on which the process of 'distillation' is continued. Invariably, modifications must be made as the reality manifests itself only in the stark reality of pen and ink. Here also, it all too often becomes necessary to make corrections. Rotring ink, unlike other Chinese inks rests on the paper without being too much absorbed by it: the CS 10 paper contains a certain amount of kaolin. This enables unwanted marks or mistakes to be removed or lines trimmed by the scalpel blade.

Except for ruling lines, mechanical pens are eschewed. A dip pen with a fine nib: a Gilott 290 is used. The tones are built up by applying tiny wedge-shaped strokes (or sharp edged elongated spots) rather than randomly scattered round spots in such a manner that the 'white spaces' receive equal consideration (bearing in mind the old typographical maxim). The darker the tone the more each stroke is reinforced or ('notched') the texture becoming juxtaposed (like the crazy pavement), reticulated or honeycombed; there is no element of random, all is deliberate.

This approach permits expression of pattern *pari passu* with varying tone. This modified stipple technique serves to bring each individual drawn to a visual 'common denominator' thereby reducing the amount of otherwise unavoidable 'mental adjustments'.

The Rotring ink, doubtless with a view to be more user-friendly toward mechanical pens, is now so quick drying as to make the ink dry on the tip of the pen before application to the paper. This renders the technique much more difficult to operate and the 'crazy pavement' effect no longer possible, or at least very difficult to execute. CS 10 paper is no longer manufactured, but tracing paper has proved an acceptable substitute.

VI: REMARKS ON THE RECONSTRUCTION OF LIZARDS

The procedure for portrayal of lizard heads essentially follows that of snakes, but must take into account the infinitely greater divergence in shapes and scalation, and modifications should be made accordingly. Lizards exhibit more characters for analysis than are available for snakes, but present proportionately as many problems in portrayal. Marking reference points with coloured ballpoint on the specimens themselves is usually unavoidable. However, no adverse effects are sustained as the marks are effaced easily when the specimens were returned to the alcohol from which they had been taken. Invariably, depending on the complexity, numbers of studies have to be made utilizing the reference points from which the drawing can be built up. Four gecko heads were treated in this manner, each taking about one and a half months apiece to complete. The scales were minute and so haphazard in their arrangement that no regular order could be determined. The specimen of *Pristurus saada* (Figure 37, a) presented an additional problem in that the scales, due to prolonged immersion in formaldehyde the pigment of the stratum corneum was eaten away obscuring the transparent scale margins, leaving very conspicuous underlying melanophores. The effect was a resemblance to so much frogspawn. The beam from the illuminator went through the scales without casting any shadows thus making recording of their margins extremely difficult. An additional problem in drawing the *Pristurus* heads (in common with geckos in general) is that, when taken out of the preservation fluid, on account of their soft bodies and small size they lose their shape very rapidly when exposed to air. In consequence the necessary studies must be made very quickly.

The foregoing comments apply to specimens in good condition. In a less than ideal specimen, (e.g. an *Agama impalearis*, indifferently preserved and somewhat emaciated) the difficulties would be such as to make a competent drawing nigh impossible: it would be more cost-effective to collect a fresh animal and preserve it 'to taste' (indeed such was the case for the specimen shown in Figure 38, a). Two families, the soft-bodied Gekkonnidae (geckos) the majority of which are very small possessing tiny irregularly disposed scales, and the Agamidae (dragon lizards) many of which may be larger and more heterogeneous, are spinous and mucronate: furthermore, the orbit and eyelids are covered with small scales. The head of a dead snake is not as very different from that of a live one: the rigours of death are immediately apparent in that of an agamid, the eyes invariably closed and, more often than not, sunken. The success of a drawing depends much more on the state of preservation of the specimen. The best results were achieved using material the present writer had preserved himself.

The *Agama impalearis* (Figure 38, a), likewise, was a "minefield' with confusing arrays of spines and varying arrangements of scales which presented problems of perspective in consequence taking substantially longer to execute. The justification for the additional effort was that, given the wide
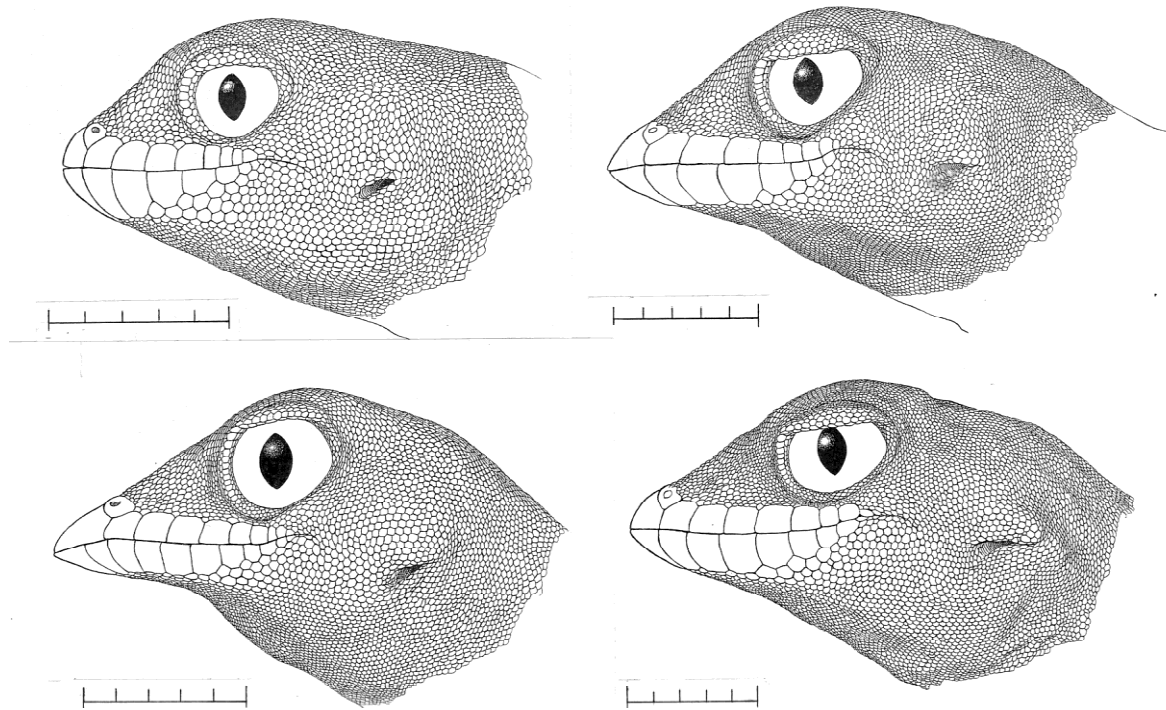
Figure 37. Heads of Arabian semaphore geckos. (**a**) *Pristurus saada* (BMNH 1963.675); (**b**) *P. collaris* (NMW 17452.3); (**c**) *P. ornithocephalus* (BMNH 1953.1.6.80); (**d**) *P. carteri* (BMNH 1953.1.8.76). From ARNOLD, 1986a. Scale in millimetres.

distribution of *A. impalearis*, intraspecific differences may be expected and could be of geographical significance.

In some species of the semaphore geckos genus *Pristurus*, in particular the *P. carteri* group, there was no obvious [immediate] taxonomic benefit in drawing all the scales of the head, there being coarse scaled and fine scaled individuals in these species (E. N. ARNOLD, personal commmunication). It was largely for aesthetic reasons that the heads were depicted fully scaled.

A similar consideration was the motivation for including the neck in full in the drawings of the head scalation of *Timon pater* (Figure 38, b), a large Algerian lacertid. The specimen was somewhat emaciated and had to be "expanded". The scales were more regular, but graded from very small to tiny, resulting in numerous subtle divisions and fusions. The *L* horizontal (reliable "constant" in most snakes) became manifest only towards the throat, being lost on the dorsum and flanks where they were replaced by a *T* (transverse), sensu BREDER (1972) series. The absence of clear cut *L* series made assessment of foreshortening of the *C* and *R* (which could be easily mistaken for the former) rows difficult. The scales involved were noted by rotating the neck in order that the numerous stages could be recorded, thereby reducing any risk of malobservation of the sequences. Misplacement of a scale usually resulted in alteration of an entire row. Extrapolations from preserved specimens themselves, would not easy, and reconstructions from road kills of such lizards would be virtually impossible.
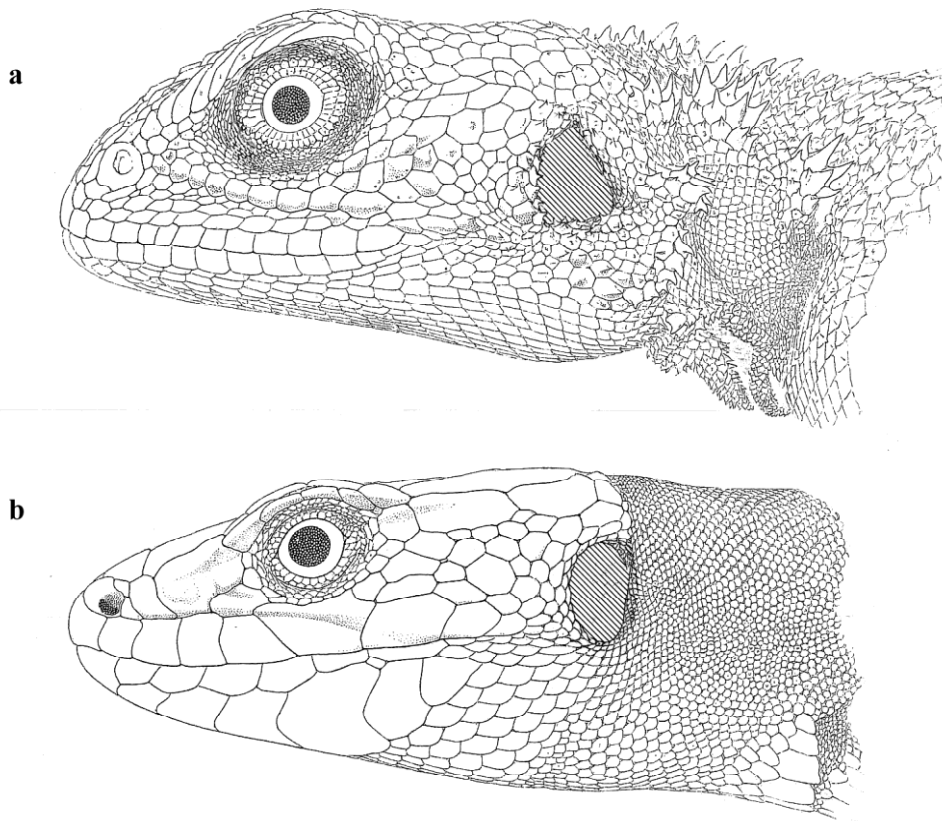
Figure 38. Left side views of the head of (**a**) *Agama impalearis* (adult male); (**b**) *Timon pater* (IPA uncatalogued).

VII: FUTURE WORK

TOWARDS A COMPREHENSIVE WORK ON ALGERIAN SNAKES. Continuing fieldwork and study of specimen specimens, has progressed but there remain many gaps in the data and understanding of the morphology and zoogeography of the species discussed earlier. In spite of the results of WADE (2001) too few specimens of the *Macroprotodon* species have been collected from the areas of contact (CROCHET & DUBOIS, 2004): it is a situation that should be remedied to eliminate the possibility of intergradation. The areas of contact between the two *Malpolon* subspecies are moderately well established in NW Algeria but tentative/uncertain in the central (Sersou Plateau) and further east of the country (Oued Soummam). More data on morphological and ontogenetic variation in the skull characters of species of both genera needs to be gathered.

Cranial and probably also hemipenial characters need to be documented for *Macroprotodon*. Limited observations, for example, on the hemipenis of *Hemorrhois hippocrepis* suggest geographic variability. Much work of similar nature remains to be done on the other colubrid species.

Addressing the regions where Algerian snakes extend into subsaharan Africa, work on the interrelationship of the psammophiine *Rhagerhis moilensis* and *R. maradiensis/cordofanensis* complex is in progress (HUGHES & WADE in preparation).

With regard to the Viperidae, the zoogeographical prediction suggested by the differences in midbody scalation in *Cerastes vipera* requires the confirmation of examination of more material.

It is also not clear whether the genus *Daboia* (*Macrovipera* auct.) in Algeria-Tunisia comprises two full species, *D. mauritanica* and *D. deserti,* as HERRMANN et al (1992) assert, or proves to be extreme examples of a cline. His samples were from Aoulouz, Morocco and Djebel Nefusa, Libya, i.e. the opposite extremities of the ranges of the putative species. The intervening area, that is most of Algeria, was not considered. The present writer has examined pallid Algerian specimens (the "*deserti*"-phase) of *D. mauritanica* from the Tlemcen, Ksar Chellala and M'Sila regions (map, Figure 24) and does not discount the differences as being clinal.

COMPUTERIZATION OF ANALYSIS OF VISUAL DATA. As has been shown above, whilst the methods developed through observation and reconstruction in concert with techniques of illustration, while bestowing an intimate understanding of the subjects, nevertheless involve a great deal of labour and are time consuming. New computational graphic/modelling techniques may provide tools many times more powerful than current methods. Digital tomography may be applied to osteological investigations without the sacrifice of valuable specimens (amongst which, in particular, the specimen of S. Tunisian *Macroprotodon* from which SALVADOR et al., 2004 extracted DNA, and type material).

Computerized methods of analysis of *iterated* data (as opposed to *visual* data) may reveal hidden, or less obvious, realities. With the advance of even more sophisticated programmes the visual realities are being similarly addressed. The interpretation of specimens in terms 'bringing them to life', could be claimed as the brain actually functioning in some sort of way as a computer albeit conditioned by experience and the consequent understanding.

In continuing the work of Appendices II and III it is desired to explore the characters of scalation in terms of their mathematics: this will also facilitate transformation for computerization addressing address features of scalation (for example the divergant scalation of Avicenna's Viper, *Cerastes vipera*, see above, Appendix III) which have been neglected by taxonomists.

The use of computer graphics is well advanced in archaeological and forensic reconstruction. This, together with the process of "building up" the face, sound knowlege of anatomy and burgeoning experience has produced remarkable results. Nevertheless, PRAG & NEAVE (1997) admit to some subjectivity and that the number of variables involved cannot guarantee "complete accuracy (...it can never be regarded as a portrait)". The success of the operation requires the involvement of two disciplines: whilst recognizing the contribution of the ultrasonic measurements and computed tomography the authors "have no doubt that the plastic skills of a sculptor with an intimate knowledge of the workings of human anatomy still remain fundamental. Richard NEAVE (personal communication) estimated that intimate understanding provided some 50% of the success during the early period of his research and 20% later, 'science' [i.e. computerized methods] having replaced it in substantial measure.

Given the time and labour involved in the drawing of complicated subjects such as small-scaled lizards, in which the scales cannot be dealt with by the method of grouping (3.2), digital scanning would indeed be a huge benefit. Whole areas of topography could be 'opened up' for analysis. But the condition of the specimen is an important consideration. The heads of three of the geckos (*Pristurus*) shown in Figure 37, b, c and d could well be treated digitally and produce results comparable to the drawn figures as the specimens were in good state of preservation. It is unlikely, or at least, questionable, that the computer could successfully scan the "frogspawn" appearance of the scales of the head in *Pristurus saada* (Figure 37, a). The same would be true for reconstruction of heads and necks of snakes as described in the preceeding pages: the procedure would involve, at the very least, very sophisticated programming. As for the reconstruction of faces, although the features and objectives are very different, the involvement of the herpetologically experienced artist likewise would seem to be an indispensable condition.

A recent publication (HÄUSER et al. 2005) on digital imaging described how specimens could be scanned. The head of a gecko was shown on line, but not in the publication, demonstrated the

effectiveness of the method. The cost/benefit balance in terms of effort would be in favour of image editing, but the result would depend on the condition of the specimen.

V I I I :   REMARKS ON *HOMOROSELAPS LACTEUS* IN M c D O W E L L (1 9 6 8)

 "*Elaps*" [=*Homoroselaps*] is a genus of small secretive snakes which, on account of possession of "fixed" front fangs were considered members of the *Elapidae*, a placement not disputed until the publication by MCDOWELL (1968) in which he aligned "*Elaps*" to the subfamily *Aparallactinae* and resurrected an earlier name, *Homorelaps* Boulenger, later amended to *Homoroselaps*, for the species *lacteus* and *dorsalis*. The aparallactine snakes are similar in size and habits to *Homoroselaps* and nearly all exhibit the 'rear-fanged' condition, i.e. where the fang is situated at the rear of the maxilla and preceeded by a series of smaller teeth. Aparallactines resemble elapids in a number of features, the most conspicuous being the lack of a loreal shield and the presence of apical pits on the body scales. MCDOWELL (1968) recognized features in *Homoroselaps* which were shared by other aparallactine genera, *Miodon*, *Polemon,* and in particular, *Chilorhinophis*: he also noted the similarity in marking of *H. dorsalis* to *Chilorhinophis carpenteri*. One of his observations was particularly convincing: the the fang of *H. lacteus* was in the same position in relation to the preorbital bone as in the rear-fanged aparallactine *Miodon collaris*, irrespective of the presence of three small teeth which preceded the fang. He further noted that an anterior projection of the maxilla in *H. lacteus* corresponded with that bearing the teeth preceeding the fang in *M. collaris* and interpreted this as an earlier rear-fanged condition. As a result of his analysis he removed *Homoroselaps* from the Elapida*e* and placed it in the Aparallactinae.

KOCHVA & WOLLBERG (1970) argued against this placement mainly on the possession of an anterior accessory venom gland, an elapid feature, in *H. lacteus* which is lacking the aparallactine species examined by them. MCCARTHY (1985) considered that some of the characters MCDOWELL (1968) used were not exclusive to *Homoroselaps* and aparallactines and others were found in other elapids. He regarded the situation as more equivocal, but placed *Homorselaps* in the Elapidae. UNDERWOOD, 1970; UNDERWOOD & KOCHVA, 1993) appeared to have settled the matter. They showed the existence of a pure cone retina in *Homoroselaps*, i.e. type A, B (double) and C cones (no rods could be recognized with certainty), whereas the aparallactines possess (as far as is known) type C cones and D (rods). They conclude that this retinal pattern placed *Homoroselaps* in "a higher grade of the Caenophidia (i.e. the "advanced" snakes) than the atractaspids [atractaspidines+aparallactines]", and thus were retained in the Elapidae. LAWSON et al. (2005), however, on molecular evidence, reversed this placement and included *Homoroselaps* within the aparallactines.

IX: GAZETEER

Localities (in bold type) cited in the text. These refer, unless otherwise stated (in capital letters), to populated places or physical features in Algeria.

Agadir, MOROCCO 30°24'N, 9°30'W

Aïn Douz 34°51'N, 1°25'W

Aïn Drahm, TUNISIA 36°47'N, 8°42'E

Aïn Sefra 32°45'N, 0°35'W

Aït Mesaoud, MOROCCO 32°24'N, 4°29'W

Aîoûn el Atrouss, MAURITANIA (Islamic Republic of) 16°40'N, 9°37'W

Algiers 36°47'N, 3°03'E

Amersid, MOROCCO 32°45'N, 4°29'W

Amsel, Hoggar 22°38'N, 5°26'E

Annaba (formerly **Bône**) 36°54'N, 7°46'E

Aoulouz, MOROCCO 30°42'N, 8°03'W

Bab el Assa 34°58'N, 2°02'W

Barika 35°24'N, 5°22'E

Batna 35°34'N, 6°11'E

Biskra 34°51'N, 5°44'E

Bordj Bou Arréridj 36°04'N, 4°46'E

Bou Sâada, 35°12'N, 4°12'E

Bou Khemissa 35°48'N, 4°33'E

Chott ech Chergui. Large salt lake in the northwest, traversed by the road from El Kreider to Bouktoub.

Chott el Hodna. Salt lake at the eastern limit of the Hauts Plateaux.

Chréa 36°25'N, 2°53'E

Dalaghan, SAUDI ARABIA 18°05'N, 42°43'E

Djebel Maâdid 35°51'N, 4°47'E

Djebel Nefusa, LIBYA. Mountain range in northwestern Tripolitania.

Djanet, Tassili-n-Ajjer 24°41'N, 9°25'E

Duirat, TUNISIA 32°52'N, 10°17'E

El Kala (formerly **La Calle**) 36°53'N, 8°26'E

El Aouedj 34°29'N, 1°15'W

El Aricha 34°13'N, 1°16'W

El Bayadh (formerly Géryville) 35°41'N, 1°01'E

El Goléa 30°34'N, 2°53'E

El Kreider (=**El Kheïther**) 34°09'N, 0°04'E

Essaouira (formerly **Mogador**), MOROCCO 31°31'N, 9°46'W

Fez (=**Fès**), MOROCCO 34°02'N, 4°59'W

Ghat, Tassili-n-Ajjer, LIBYA 24°58'N, 10°09'E

Guelt es-Stel 35°09'N, 3°02'E

Hoggar (=**Ahaggar**). High massif in the south (Central Sahara)

Hammam Meskoutine 36°27'N, 7°16'E

Jerez de la Frontera, SPAIN 36°41'N, 6°08'W

Khenget Sidi Nadji 34°49'N, 6°42'E

Khnifiss Lagoon (?**Foum Agoutir**), MOROCCO 28°00'N, 12°14'W

Kordofan, SUDAN: Sahelian province situated west of the Nile.

Ksar Chellala 35°13'N, 2°41'E

Laayoûne (=**El Ayun**), SAHARA OCCIDENTAL 27°09'N, 13°12'W

Laghouat 33°48'N, 2°53'E

Larache (=**El Arache**), MOROCCO 35°12,N, 6°09'W

Mâarif 35°23'N, 4°18'E

Maradi, NIGER 13°30'N, 7°06'E

Marrakesh, MOROCCO 31°38'N, 8°00'W

Maryut, Alexandria, EGYPT 31°01'N, 29°48'E

Méchéria 33°33'N, 0°17'W

M'Sila 35°42'N, 4°33'E

Moila (=**El Muwaylih**), Midian, SAUDI ARABIA 27°41'N, 35°27'E

Oued Chélif. Large river whose estuary lies some 13 km N of Mostaganem and proceeds due east almost as far as Médéa whence it turns southward (as O. Nahr Ouassel and O. Touil) to their sources in the Djebel Amour.

Oued Dra', MOROCCO. Large river, dry for a large part of its length for most of the year in the south, whose estuary is some 25km along the coast from Tan Tan Plage. Its valley separates the Anti Atlas from the Dj. Ouarkziz and extends to the southern foothills of the High Atlas to its confluence with the O. Dadès near Ouarzazate.

Oued Moulouiya, MOROCCO. Large river in the northeast whose estuary lies between Ras el Ma and Saïdia, following a southwesterly course, separating the Middle Atlas, and the Mediterranean region from the Saharan, and also, *Macroprotodon brevis* from *M. cucullatus* and *Malpolon monspessulanus monspessulanus* from *M. m. insignitus*.

Oued Nahr Ouassel. A westward branch of the O. Chélif. It borders the northern part of the Sersou Plateau and could represent one of the demarcation lines between the two subspecies of *Malpolon monspessulanus*.

Oued Soummam. A river which (including its upper reaches, the O. Sahel and O. Eddous) separates the Petite from the Grande Kabylie. It could represent one of the demarcation lines between the two subspecies of *Malpolon monspessulanus* in the east.

Oued Touil. Upper reaches of the O. Chélif, probably representing the line of demarcation between populations (Ksar Chellala) of *Macroprotodon abubakeri* and *M. cucullatus*.

Oulmès les Thermes (=**Tarmilète**), MOROCCO 33°24'N, 6°24'W

Saïdia, MOROCCO 34°06'N, 2°13'W

Sebdou (Wilaya de Tlemcen) 34°38'N, 1°20'W

Sersou, Plateau de 35°30'N, 2°00'E

Sidi Djillali 34°28'N, 1°35'W

Sidi Fredj (=**Sidi Feruche**) 36°43'N, 3°30'E

Smara, SAHARA OCCIDENTAL 26°44'N, 11°41'W

Souk Thnine (Wilaya d'Aïn Témouchent) 35°14'N, 1°30'W

Tabarka, TUNISIA 36°57'N, 8°46'E

Tal Terny (Wilaya de Tlemcen) 34°45'N, 1°21'W

Tassili-n-Ajjer. High mountain range north of the Massif du Hoggar extending approximately from Amguid into Libya.

Tatahouine, TUNISIA 32°54'N, 10°27'E

Ténéré, "bordure est du Taghmert", NIGER 19°0'N, 9°15'E (approximately)

Tiérni (Wilaya de Tlemcen) 34°48'N, 1°22'W

Tlemcen 34°52'N, 1°19'W

Tripoli, LIBYA 32°53'N, 3°10'E

Umm Ruaba, Kordofan, SUDAN 12°54'N, 31°13'E

Zaranik, Northern Sinai, EGYPT 31°08'N, 33°28'E