THE FORENSIC IDENTIFICATION OF CROCODILIAN HIDES AND PRODUCTS

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INTRODUCTION

The conservation and management of wildlife, including crocodilians, is usually based upon an assessment of the status of endemic populations and those factors which have impact upon the survival of the species. Adverse factors may often be negated by manipulating the habitat or the makeup of the species populations, or by protecting the species from outside or unnatural pressures which may be detrimental in themselves or may amplify the effect of other negative factors. The latter may be achieved by the enactment of local, national or international laws which limit or prohibit the taking or utilization of the species for personal or commercial purposes.

While biologists and other scientists may define the ecological or environmental problems, legislators may be called upon to enact the legal solutions, while law enforcement authorities are charged with enforcing and judicating compliance. The effectiveness of wildlife conservation and management programs is contingent upon the integrated workings of all three. The ability of the forensic scientist, in applying scientific fact to the legal problems which arise, is often an important catalyst.

Crocodilians pose unique problems in conservation, management, and wildlife law enforcement (Brazaitis 1984), and to the forensic herpetologist. Of the 21 traditionally recognized species found throughout the tropical and sub-tropical regions of the world, 15 or more forms may be exploited commercially. They provide a major source of raw material and a significant economic basis for the world exotic leather industry. The trade is estimated to utilize about 1.5 million skins annually, three quarters of which include skins of South American species. A large number are taken illegally in violation of national wildlife regulations (Hemley and Caldwell 1986). Harvest quotas, size limits, or regional protections (Fuller and Swift 1984, Groombridge 1982) may frequently be disregarded. These constitute the major types of violations in addition to the contraband trade in endangered species.

The international trade in crocodilians is regulated under the Convention on the International Trade in Endangered Species of Wild Flora and Fauna (CITES) promulgated in 1973, and in the United States, trade is regulated under the Lacey Act of 1900 (amended 1981) and the U.S. Endangered Species Act which was revised in 1973 to implement CITES regulations. Under U.S. law, violations may result in simple seizure of goods for improper documentation, denial of

importation, forfeiture of goods, civil penalties or prosecution under felony charges. Lacey Act violations may result in penalties of up to U.S. $20,000 and up to five years imprisonment for each count charged.

The amount of illegal trade, if we consider all types of violations as constituting an illegal transaction, appears to be inconsistent with the extensive amount of national and international regulation. This may, in part, be due to the fact that most skins are taken from wild populations endemic to poor or developing countries, which may be under enormous economic pressures. Such countries may be least able to afford extensive management or law enforcement programs. Second, hides and products may be shipped and re-shipped through many ports and countries before arriving at final destinations and markets. Third, closely related species from different origins may be difficult to distinguish from each other in their processed form. Whole skins or cut up pieces of skin from different species or races of different origins may be mixed in tanning, shipping, or ultimately during their manufacture into products. Last, wildlife authorities often find it difficult to trace individual skins or the skins combined on products back to their native sources as nearly all such skins lack identifying marks or tags. Authorities may need to rely on export or re-export documents which list numbers of skins of designated species. Only skins of the American alligator bear individual identifying tags which must remain affixed to the hide through the tanning process and up to the time the hide is manufactured into a product.

The problems are exacerbated when wildlife authorities, confronted with the unpopular task of having to enforce foreign wildlife regulations, are beset by pressures from those who view the strict application of regulations which affect commercial trade as obstacles to free enterprise. The national debt, deficits in foreign trade and weakening national economies all may be given priority. Wildlife law enforcement budgets may be the first to suffer for lack of financial support. The extent to which forensic techniques are applied in developing prosecutions may become particularly restricted.

Few published manuals exist which deal with the identification of crocodilians, their hides and products (King and Brazaitis 1971b, Brazaitis 1973, Brazaitis and King 1984, Fuchs 1974, Wermuth and Fuchs 1978, 1983); yet, the availability of biologically accurate manuals is most important for the training of wildlife officers who must apply this information in day to day field investigations involving a wide assortment of skins and products, each with its own peculiar problems in species identification. Some commercially sponsored manuals have only served to compound the problems of enforcement by presenting taxa based on commercial material, often of unknown specific origins (Fuchs 1974, Wermuth and Fuchs 1978, 1983) rather than scientifically accredited study material. A number of taxonomic citations which have been included without broad scientific peer review have drawn considerable criticism from the scientific community (Frair and Behler 1983, Brazaitis and King 1984, Ross and Mayer, pers. comm.).

Standard taxa providing the basis for the identification of crocodilians, their hides and products, and the basis for U.S. law enforcement efforts, are presented in Brazaitis (1973b, Groombridge (1982), King and Brazaitis (1971), Medem (1981, 1983), Wermuth (1953) and Wermuth and Mertens 1961).

Common names, local native names, and the commercial nomenclature for crocodilians are given in Fuchs (1974), Fuchs and Wermuth (1978), Groombridge (1982), King and Brazaitis (1971), Brazaitis (1973b) and Medem (1981, 1983).

Current status of wild populations and distributions are presented in Groombridge (1982), the Proceedings of the IUCN Crocodile Specialist Group and the Bulletins and Newsletters of TRAFFIC, the Wildlife Trade Monitoring Unit of IUCN.

Legal protections are given in Fuller and Swift (1984) for Latin American countries, Groombridge (1982), TRAFFIC bulletins and newsletters and in the U.S. are published regularly in the Federal Register by the U.S. Fish and Wildlife Service. The Federal Register also regularly publishes changes in foreign wildlife regulations as well as changes in enforcement policies.

An overview of tanning techniques and hide processing is presented by Fuchs (undated) and in Wilson (1928, 1929).

The Forensic Examination of Wildlife Products

Wildlife and wildlife products generally enter or leave the United States through certain designated ports which are staffed with agents and inspectors of the U.S. Fish and Wildlife Service. Invoices, manifests and customs declarations pertaining to wildlife shipments are referred to wildlife inspectors who may elect to make a personal inspection of the shipment. Inadequate documentation, discrepancies between the country of origin and the known distribution of the species listed or the presence of a species which is grossly similar to a prohibited endangered form, may result in the shipment being refused entry into the country or it may be detained for further examination. A random sampling of the contents of the shipment may then be taken for forensic examination. The examination may be made by trained agents or inspectors within the service, or items may be presented to an independent forensic examiner. Given the thousands of dollars often involved in shipments of wildlife products, unnecessary delays and damage to the detained items are avoided.

In the interest of objectivity, forensic examiners should be deprived of all knowledge of the origins and species citations invoiced for the items, the names of the companies or owners involved and generally the extent of the investigation. Identifications must be made solely on the basis of the physical evidence presented. The examiner should bear in mind that his or her conclusions must reflect only those facts which have been physically determined and which can be substantiated and presented without reservation in any future court proceeding. Thus, although the examiner may believe the characteristics displayed on a pair of shoes suggest a particular race or subspecies, his examination must be definitive and rely only on positive characteristics. There is little room for subjective interpretation. If, based on the examiner's report, a violation is confirmed, the examiner may then be called upon to make a comprehensive inspection of the shipment and ancillary documents, and may later be called upon to testify as to his findings. Common, commercial and scientific names invoiced, skin sizes relative to the lengths commonly attained by the species in life, origins cited and actual distributions for the species involved, types of tannage, stamps and other markings, all may be scrutinized and compared to known standards for possible additional supporting evidence. The role of the forensic examiner is to provide the unbiased scientific facts, which he has determined to the best of his ability, that will elucidate the legal contentions (Brazaitis 1986b).

Categories of Commercial Skins in Trade

The manner in which raw crocodilian skins are prepared prior to processing is determined by the amount and body location of usable skin on the particular species involved, the use to which it will be put in the manufacture of products, the preferences of the market for which the product is intended and, in some instances, the customs of the hunter who procures the skin from the animal.

In the United States, various state laws mandate that American alligators be skinned and shipped with different small portions of skin left attached to help distinguish the harvest year in which the skin was taken. A number of countries are adopting similar skinning variations into management protocols.

Most crocodilians are utilized as whole belly skins which are sold by the piece or by the belly width. They are skinned in the traditional manner, discarding the hard bony scales of the back, dorsal neck and tail, and feet. The remaining commercially desirable portion includes the skin of the lower jaw and throat, belly, complete with as much flank skin on each side as possible and as much of the ventral and lateral portions of the tail as possible (Fig. 1 A).

An alternate method of skinning produces a "hornback." By this method, the animal is skinned via a longitudinal mid-ventral incision which preserves the neck, back and anterior dorsal tail scalation (Fig. 2). Native crafts from West Africa and Latin America as well as moderate quality products produced or marketed in Japan and southeast Asia utilize hornback skins.

Although *Melanosuchus niger* is skinned in the traditional manner, the tanned and finished skins may often be cut up into sections and sold as throats, chests, bellies, girdles and tails, as well as whole skins, by the piece or square measure (Fig. 1 D).

The various races of spectacled caiman *Caiman crocodilus* may either be skinned in the traditional manner, or only the flank regions may be taken (Fig. 1 B). Flanks include the softer, less ossified skin between the front and rear limbs and the dorsal and ventral scales. Occasionally, the two flanks are left joined by the skin of the gular and pelvic regions. The tail is cut off immediately posterior to the vent and is discarded, along with the mid-ventral belly region. More often, each flank is shipped as independent pieces packed in bundles. Half tanned crusts as well as tanned and finished caiman flanks may be shipped directly from South American tanneries to manufacturers around the world. Flanks may be invoiced and sold by the piece or by the square measure.

Total maximum and average lengths for crocodilians are given in Brazaitis (1973b), King and Brazaitis (1971), and Groombridge (1982). The length of the flank skin, from axilla to groin (Fig. 3F), may be used as an index in determining the approximate size of the animal from which the flank was taken, and may help to distinguish the flank skins of large species from those achieving only small to moderate lengths. For caiman, this straight line measurement from axilla to axilla approximates 22 % of the total length of the animal. Thus, a flank length of 40 cm would indicate it was taken from an animal about 182 cm in total length. Comparable flank proportions may be used to approximate lengths for races of *C. crocodilus*, *M. niger*, and *Alligator mississippiensis* (Brazaitis, in prep.). Hide grading by quality, skinning methods, proportional amounts of usable skin for different types of crocodilians and methods of measuring commercial skins are given in Fuchs (undated) and Van Jaarsveldt (unpubl.).

Scraps and trimmings are small pieces of skin from any species, which may remain after whole skins, flanks, etc. are cut up in the manufacture of products. Scraps may be in the form of crust or completely tanned and finished skin. Scraps are often sold by weight (Fig. 1 C).

The Species Identification of Crocodilian Skins

The identification of crocodilian hides and products relies largely on the determination of gross morphological characteristics, although more sophisticated biochemical methods of

identification are currently under investigation. Figure 4 shows the regions of body scalation referred to in the following identification procedures and keys. Figure 3 shows the scale configurations and patterns at various body regions. Numbers of scale rows, scale inclusions in certain body regions and the shape and arrangement of scales may be definitive in themselves or in conjunction with other characters.

There are two basic characteristics which serve as fundamental criteria in the identification of crocodilians in life, as skins or hides, or as manufactured products. These are the presence or absence of integumentary sense organs (ISOs) on the body scalation (Fig. 5A, B), and the presence, composition, degree, or lack of bony plates or osteoderms in the ventral body scalation (Fig. 6).

Only members of the families Crocodylidae and Gavialidae have integumentary sense organs. All members of the family Alligatoridae lack ISOs on body scales. However, all crocodilians bear ISOs on various portions of the head. While having a single ISO on each scale is the general rule, as many as two to five may be found on ventral scales. When present, ISOs can be found on the anterior middle portion of the body scales in living animals, and in all forms of processed skins and products.

Osteoderms (Fig. 6) are body plates which occur in parts of the body scalation of all crocodilians. However, as a diagnostic tool, we only consider those osteoderms which occur in the ventral regions of the throat, pectoral and belly scalation. There are two types: composite osteoderms, which are made up of two or three sutured plates (Fig. 6A) such as those found in the genera *Caiman*, *Melanosuchus* and *Paleosuchus*, and single bone osteoderms such as those found in the genera *Alligator*, *Crocodylus* and *Osteolaemus* (Fig. 6C, D). Shaving and processing enhances the ability to determine the presence and type of ventral osteoderms in hides and products. While processing may change the texture and thickness of the skin and scalation, the form of the scales and their relationship to each other remains the same. Appendix I gives a key for the identification of commercial crocodilian hides and skins based on body scalation. Although the key focuses on whole belly skins, the scale morphology may be applied in the identification of flanks, cut pieces of skin and manufactured products presented in commercial trade. In doing so, it is of utmost importance to determine the specific body region from which the skin represented on the product has been taken (Fig. 3). The key is adapted from (Brazaitis 1973a, b), King and Brazaitis (1973) and Ross and Ross 1974). The morphology presented in this paper reflects the classic identifying characteristics of the species involved.

Types of Crocodilian Products in Trade

Crocodilian products commonly found in trade include dried, salted, or raw untanned whole skins or skin parts; partially tanned skins termed "crusts" (Fig. 12 C); fully tanned and finished whole hides, portions of hides and trimmings from manufacturing procedures; manufactured products; trophy skins and skulls; novelty items and curios. Manufactured products and tanned skins may be of moderate or high quality commercial manufacture, which are widely exported, or of poor quality native craft. Novelty items, curios and trophy skins are usually of native craft and are largely directed at the local consumer or tourist, although in recent years such items have found a sales market in low income shops and street vendors in the U.S. and Europe.

Manufactured products include handbags, shoes, wallets, belts, attache cases and small pieces of luggage, watchbands, key cases and billfolds. These make up the bulk of and economic basis for the crocodile leather trade. Quality commercially tanned and processed hides and products are

generally characterized by their soft supple leathers, uniform coloration and texture, and careful workmanship combined with polished metal fittings.

Quality handbags and other items are fabricated from matched panels of selected belly skins while gussets and hide panels are matched with sections of tail, neck or selected leg skin (Figs. 3, and 7). France, Italy, Switzerland and West Germany are the centers of quality fabricating and tanning of crocodilian skin. In general, highest quality or "classic" skins are used in the manufacture of the highest priced products. These are from species which lack or have poorly developed bony plates or osteoderms in the ventral areas. They produce soft supple leather and have scale patterns which are aesthetically pleasing when processed. Highly desirable classic species include the American alligator *A. mississippiensis*, Nile crocodile *Crocodylus niloticus*, salt-water crocodile *Crocodylus porosus*, New Guinea crocodile *Crocodylus novaeguineae novaeguineae*, Morelet's crocodile *Crocodylus moreleti*, the Siamese crocodile *Crocodylus siamensis*, and frequently the black caiman *M. niger* and the broad-snouted caiman *Caiman latirostris*.

Shoes are usually made from young crocodilians with small scales. Scraps or trimmings are often used for toes, heels and straps, although entire shoes are commonly composed of pieces of flank skins of caiman *C. crocodilus* (Fig. 1B and C). Most quality caiman shoes are manufactured in Italy from the wide flanks of Yacare caiman *Caiman crocodilus yacare*. Tanned and finished Yacare flanks may be shipped from Bolivia, which have frequently been taken from animals often killed illegally in Brazil (Hemley and Caldwell 1986).

Quality billfolds, wallets, desk sets, etc. are made from neck, throat flank and tail sections of black caiman (Fig. 1D), American alligator and caiman. Two to four belly skins of juvenile dusky caiman *Caiman crocodilus fuscus*, often shipped from Colombia in disregard of minimum size limitations, may be used in the manufacture of a single wallet and are sewn side by side on a wallet or billfold.

Most belts are composed of small scraps of skin (Fig. 1C), usually caiman, carefully matched to conceal the seams and backed with steer leather. The seams between pieces in quality belts are well matched. The forensic examiner must have a thorough knowledge of scale configurations from crocodilian body regions, and must carefully scrutinize the product if a species identification is going to be possible on such items.

Watchbands are generally composed of scraps or trimmings (Fig. 1C) of nearly any species, but primarily of caiman *C. crocodilus*.

In recent years, softer body portions of the heavily ossified members of the species *C. crocodilus* have increasingly been used in the manufacture of better quality products. South American skins are shipped to South Africa, Japan and Southeast Asia and are often documented as endemic true crocodile species after manufacture into products. Many are misleadingly sold to visiting tourists as well, under the name of the familiar endemic species.

Figure 2 shows the typical "hornback" look of products manufactured in Southeast Asia and Japan. These are not truly native crafts, although they do not reflect quality commercial manufacture. The skins are not well tanned and tend to be hard and somewhat inflexible. Rather than displaying the ventral portions of the crocodilian as the focal point of front and rear panels, the coarse back scalation of an animal skinned through the belly is the prominent feature. The bony keeled dorsal scales preclude burnishing and finishing, thus the back scales are left dull while the remainder of the skin is finished to a high gloss. Species most often used include caiman *C. crocodilus*, the salt-water crocodile *C. porosus*, Johnston's crocodile *Crocodylus johnsoni*, the Siamese crocodile *C. siamensis* and infrequently, the Malayan false gavial *Tomistoma schlegeli*.

Native crafts reflect the opposite traits of quality products. Native crafts generally utilize local tanning materials and can be identified by their uneven "hardness" due to hand processing and inconsistent times spent at various steps in the tanning process. Many skins and products are left in bleached-out neutral tones. The uneven suppleness and thickness of the leather, combined with disregard for controlled tanning chemistry, preclude the uniform absorption of dyes. The effect when dyed is a blotchy uneven appearance. Linings may be of similar poor quality domestic leathers while borders and seams may be wrapped with leather thongs. Latches and fasteners are usually of leather as well. Holes in skins may simply be plugged with a glued-on patch. A number of reptile species may be combined with crocodilians; favorites include python (Boidae), monitor lizard (Varanidae) and sea turtle (Cheloniidae). While nearly any species of crocodilian may be utilized in native crafts and sold locally, African species and products from western Africa have the widest sales distribution and are often presented to the forensic examiner for identification. These include the west African dwarf crocodile *Osteolaemus tetraspis*, west African slender-snouted crocodile *Crocodylus cataphractus*, and the Nile crocodile *Crocodylus niloticus*.

Characteristics of Frequently Utilized Species As They Commonly Appear on Manufactured Products

The dwarf crocodile *Osteolaemus tetraspis* of west Africa is often used in the production of poor quality native crafts, such as handbags and carrying cases. Its flanks are distinctive and are often prominently displayed on products. The species has ISOs, and in addition, has large keeled scales arranged in a random fashion in a field of creased skin (Fig. 3F[2]). The characteristic nuchal cluster on the back of the neck (Fig. 8C) is made up of a group of four scales arranged in a square. Ventral scales are arranged in 18 to 22 transverse rows. The belly skin is extensively ossified, containing single osteoderms (Fig. 6C) and is not easily dyed, shaved thin or decalcified in tanning. Products are stiff, often bleached in color and frequently are left in neutral tones or sometimes dyed black or red.

The Nile crocodile, *C. niloticus*, and the west African slender-snouted crocodile, *C. cataphractus*, both occur in trade and bear ISOs. While some populations of Nile crocodiles do not bear osteoderms in the ventral scalation, others do. These latter animals contain poorly developed but diagnostic small elliptical osteoderms in the gular or pectoral regions of the skin (Fig. 6D). In contrast, *C. cataphractus* has extensive round osteoderms in nearly all of the ventral scales. These osteoderms can be clearly seen as flattened hard reflections under the surface of the glossy smooth scales in tanned skins and manufactured products (Fig. 6C and D) and as larger hard bony plates in native crafts.

Base plates and gusset portions of handbags may contain tail portions which display mid-ventral rows of irregular scales extending caudad from the cloaca (Fig. 9D), characteristic of the Siamese crocodile *C. siamensis*. The species lacks ventral osteoderms but has ISOs.

Inclusions of extra scales between the rows of scales on the ventral anterior portion of the tail are diagnostic for other species of crocodilians as well, and are often found under careful scrutiny on shoes as well as larger items. Transverse ventral inclusions with ISOs (Fig. 9A) identify the sub-caudal tail skin of Morelet's crocodile *C. moreleti*.

The tail skin of *Crocodylus acutus*, the American crocodile, can be identified if the inclusions are restricted to the lateral portions of the tail as in Fig. 9C (Ross and Ross, 1974).

The tail skin of black caiman *M. niger* is equally identifiable. Although the inclusions are similar to those of the Morelet's crocodile, the black caiman lacks ISOs.

Irregular swirling trails found on the ventral scales, including the tail scales of many crocodilians throughout the world, were once thought to be characteristic of the Orinoco crocodile, *Crocodylus intermedius* (Fig. 5C). They are, however, produced by a parasitic nematode of the genus *Capillaria* (H.I. Jones, pers. comm.) and are not diagnostic.

Nuchal scalation (Fig. 4A) may also be diagnostic for certain species. Nuchals are often prominently displayed on native crafted as well as poorly manufactured hornback products (Fig. 2) and hornback skins. The square block like nuchal formation Fig. 8C) of *O. tetraspis*, the west African dwarf crocodile, is unique, and combined with the presence of ventral osteoderms, ISOs and flanks composed of randomly arranged keeled scales in a field of soft creased skin (Fig. $3F^2$) is diagnostic.

A typical *Crocodylus* nuchal cluster (Fig. 8A), combined with connective scales so as to form a continuation of the dorsal scales (Fig. 8E) identifies *C. johnsoni*, the Johnston's crocodile. The flanks are composed of uniform rows of round scales similar to those in Fig. $3F^1$. ISOs are present as are well developed ventral osteoderms.

The nuchal formations of the west African slender-snouted crocodile (Fig. 8F) and the Malayan false gavial *T. schlegeli* (Fig. 8D) are similar, however, the former species has ventral osteoderms while the latter does not.

Although the Indian gavial *Gavialis gangeticus* has not entered trade in many years, perhaps it should be noted that it does have a nuchal formation similar to *Tomistoma* and *C. cataphractus*, however it differs in having uniform rows of square or hexagonal flank scales as opposed to round or oval flank scales.

The saltwater crocodile, *C. porosus*, which has a typical *Crocodylus* nuchal formation (Fig. 8A) may sometimes be identified by the lack of post occipital scalation (Fig. 4A). In addition, the species lacks ventral osteoderms and has flank scalation arranged in uniform length rows similar to Fig. $3F^1$. There are 30 to 35 transverse ventral rows of scales. The skin of this species produces the finest of crocodilian leathers.

The nuchal clusters of members of the genus *Caiman* and *Melanosuchus*, as well as *A. mississippiensis* are distinctive (Fig. 8B). However, the family Alligatoridae displays other characteristics as well.

Members of the family Alligatoridae may be separated from other crocodilians by their total lack of body ISOs. ISOs are restricted to the head only. Although most alligatorids have ventral osteoderms, the American alligator usually has only poorly developed single osteoderms in the pectoral and midventral regions, if at all (Fig. 6C and D). The surface of the skin assumes a smooth finish when tanned. The scar remaining from the umbilicus in this species remains throughout life as a fine network of creases (Fig. 7), and can usually be seen near the top of at least one face panel on larger purses and handbags.

The black caiman, *M. niger*, differs in having a composite square osteoderm in nearly all of the ventral scales (Fig. 6A). The surface of the ventral skin is highly polished, smooth, unpitted and somewhat inflexible. Like all alligatorids, it lacks body ISOs. The inclusions between the ventral scale rows under the anterior tail are definitive (Fig. 9B). The flanks are composed of six to eight rows of large, round, poorly keeled scales, alternating with rows of small scales (Figs. 10C

and D). Manufactured items include handbags, wallets, billfolds, men's shoes, attache cases and desk top accessories. The skin of the species is often too valuable to be sold in small pieces (Fig. 1D). Most skins originate from Bolivia but they are taken from neighboring countries.

Caiman also lack body ISOs end have large, square, composite bony osteoderms in the ventral scales as do the black caiman, but differ in that when tanned, the belly scales display deep surface pitting (Fig. 6B) in typical glossy finishes. Caiman may be tanned to a high gloss finish or as suede like sauvage finishes. Osteoderms are clearly visible on the inside and outside surfaces of the skin (Fig. 6A and B). Bombe finishes usually produce a wrinkling effect surrounding a raised "button" on the outer surface of ventral scales.

The ventral scales of *C. latirostris*, the broad-snouted caiman, show extensive surface pitting (Fig. 6B) when tanned. The trunk is wide, and is often used as a whole belly skin. The flank scales are composed of a single row of rectangular large keeled scales, followed by one or two alternating rows of large rectangular and small bead-like scales (Fig. 10A and B). There are no tail inclusions. The composite ventral osteoderms take processing well. Unlike products from other members of the caiman group, products may feel soft and more compressible to the touch.

The most commonly utilized crocodilians are the races of *C. crocodilus* of South America, except for the Rio Apaporis caiman, *Caiman c. apaporiensis*. These animals are closely related and widely distributed. The skins are collected throughout South America from a multitude of regions. Skins are mixed during tanning and are shipped as mixed species to consuming and manufacturing countries. Raw skins are also shipped to tanneries in Italy and France, where they again are mixed and re-exported to other countries. Most skins are unmarked and are often taken in violation of national wildlife regulations which often include harvest limits and size limitations.

While it is relatively easy to distinguish the dark raw skins of the yacare caiman, *C. c. yacare*, from the yellow green skins of the common caiman, *C. c. crocodilus*, or the dusky unicolor skin of *C. c. fuscus*, tanned but unfinished bleached skins, and tanned and finished hides may be difficult to separate on a subspecific level. All lack sensory organs, all have surface pitting (Fig. 6B), all have extensive composite square ventral osteoderms (Fig. 6A) and none have ventral tail inclusions is such as those found in the black caiman.

They do differ in flank scalation. While black caiman has six to eight rows of alternating small and large round unkeeled scales (Fig. 10B and C), the yacare caiman has flanks composed of three to five rows of round nearly unkeeled scales separated by "chain-like" interscales (Fig. 11). The rows are largely uniform in longitudinal arrangement.

C. c. crocodilus, the common caiman, usually bears a row of enlarged strongly keeled oval flank scales, followed by one or two series of oval keeled scales separated from each other in a field of soft skin creases containing small round scales (Fig. 12).

We do not include the Rio Apaporis caiman *C. c. apaporiensis* in this discussion as the species has already been largely extirpated by commercialized hunting and is no longer found in international trade.

The dusky caiman, *C. c. fuscus*, is similar to the common caiman, except the flank rows tend to be uniform in arrangement and are separated from each other by a series of small bead-like scales (Fig. 13). Juvenile dusky caimans are frequently taken from Colombia under the 1.2 m size limit and are tanned into wallets. As many as four belly skins may be used in a single men's wallet. Many are sold as curios and novelties and originate in Mexico, Colombia and Panama.

The wide flanks of the yacare caiman *C. c. yacare* are the most often utilized. Flank scalation is usually composed of four rows of round or oval poorly keeled scales separated by a chain like pattern of creased skin and small scales (Fig. 13). Single shipments of two to three thousand whole flanks are not uncommon, and are not difficult to identify. However, when caiman skin scraps are pieced together and fastened to steer leather, only the deeply pitted surface of the underlying ventral osteoderms is available to make a determination. In this case, the only identification which may be made is that it is a member of the family Alligatoridae and of the genus *Caiman*.

The genus *Paleosuchus* rarely is found in any appreciable numbers in commercial trade, and then only as stuffed curios. Belly scales are the most extensively boned, with composite osteoderms that overlap successive scales to form an impervious armor, which makes commercial processing uneconomical. Ventral scales are in 18 to 24 transverse rows.

Crocodilian Skin Reproductions

With the rising cost of quality crocodilian skin, a number of techniques have been developed for reproducing genuine crocodilian skin patterns on domestic leathers and plastics. The results have been moderately successful in that, in some cases, the species from which the type was taken is readily identifiable on the artificially manufactured product. To the untrained examiner, artificial skin may be mistaken for the genuine product. Chemical or spectroscopic analysis may be used to determine the presence of plastic components. However, artificial products are relatively easy to separate from their genuine counterparts if a few basic principles are kept in mind.

Domestic leathers which are embossed with crocodilian prints are done so from prepared stamps or molds. Thus, the scale patterns are repetitive, and body regions are often displayed with body regions they are not associated with in life. Creases between scales and junctures lack the ultra-fine detail, uniqueness and individuality of different living animals. Bony scales, expected to be hard and unyielding, such as dorsal and nuchal scales, are often as soft as surrounding scales. Examination with a hand lens often reveals pock marks and blistering on the surface of the product as a result of high temperature molding processes. Turning small pieces of surface material may result in an odor of burning hydrocarbons, indicating plastic, rather than the odor of burning keratin such as hair or feather.

The Identification of Crocodilian Skins by Biochemical Techniques

The biochemical identification of wildlife is in its infancy. However, systematics investigations into the molecular identification of crocodilians have been carried out on blood (Densmore 1983) and meat and blood (Joanen, pers. comm). Forensic biochemical investigations are underway under the joint auspices of the New York Zoological Society, Long Island University and World Wildlife Fund (USA). An overview of the application of current biochemical techniques is presented in Brazaitis (1986a). A bibliography of the applications of forensic science in wildlife law enforcement is given in Wilson, 1978).

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APPENDIX I

Key to the Identification of Whole Raw, Crusts, Tanned and Finished Skins (adapted from King and Brazaitis 1971, Brazaitis 1973b).

1. a) Ventral scales with integumentary sense organs (=ISOs) (Fig. 5A) 2
   b) Ventral scales lacking ISOs 10

2. a) Osteoderms (Fig. 6) present in ventral scales, at least in pectoral regions 3
   b) Osteoderms absent from all ventral scale regions 6

3. a) Ventral scales in 22 to 24 transverse rows ..... *Crocodylus johnsoni*
   b) ventral scales in 25 to 32 transverse rows 4

4. a) Flank regions (Fig. $3F^2$) adjacent to the ventral belly region composed of soft creased skin containing few randomly located well developed keeled scales ..... *Osteolaemus tetraspis*
   b) Flank regions adjacent to the ventral belly region composed of round or oval well developed scales which are arranged in more or less organized rows (Fig. $3F^1$) 5

5. a) Ventral scales in gular, pectoral, and mid-belly and subcaudal tail regions containing large round osteoderms (Fig. 6C) ..... *Crocodylus cataphractus*
   b) Ventral scales in pectoral and some mid-ventral scales with feeble small elliptical osteoderms (Fig. 6D) ..... *Crocodylus niloticus*

6. a) Anterior subcaudal tail regions lacking scale inclusions 8
   b) Anterior subcaudal tail scale inclusions present (Fig. 9) 7

7. a) Scale inclusions extending from the posterior vent, medially through the first several rows of subcaudal tail whorls (Fig. 9D) ..... *Crocodylus siamensis*
   b) Scale inclusions on the lateral portions of the anterior tail, extending across onto the ventral and mid-ventral tail regions Fig. 9A) ..... *Crocodylus moreleti*
   c) Scale inclusions on the lateral portions of the anterior tail only (Fig. 7C ..... *Crocodylus acutus*

8. a) Flank scales (Fig. 1, 5) adjacent to belly scales square or hexagonal in shape ..... *Gavialis gangeticus*
   b flank scales adjacent to belly scales round or oval in shape 9

9. a) Ventral scales in 24 or fewer transverse rows ..... *Tomistoma schlegeli*
   b) Ventral scales in 24 to 26 transverse rows ..... *Crocodylus novaeguineae novaeguineae*, ... *Crocodylus mindorensis*
   c) Ventral scales in 26 or more transverse rows ..... *Crocodylus intermedius* (26-28)
   ..... *Crocodylus rhombifer* (29-33)
   ..... *Crocodylus palustris* (28-32)
   ..... *Crocodylus porosus* (30-33)

10. a) No osteoderms present in belly scales, or an osteoderm composed of a single bone (Fig. 6C, D) 11
    b) Osteoderms present in belly scales as a composite bone made up of at least two sections (Fig. 6A) 12

11. a) Umbilical scar present in all sizes, appearing as a network of fine creases (Fig. 7); ventral scales in 29 or more transverse rows ..... *Alligator mississippiensis*
    b) Umbilical scar absent, ventral scales in 28 or fewer rows ..... *Alligator sinensis*

12. a) Ventral scales lack surface pitting 13
    b) Surface pitting present (Fig. 6B) 14

13. a) Subcaudal tail inclusions present (Fig. 9B); flank scales as in Fig. 10B, C; ventrals in 25 or more rows ..... *Melanosuchus niger*
    b) Subcaudal tail inclusions absent, belly scales in 24 or less rows ..... *Paleosuchus palpebrosus*, ... *Paleosuchus trigonatus*

14. a) Ventral collar scales (Fig. 4) not noticeably enlarged, composed of a double row of scales; belly scales in 26-30 transverse rows; flank scalation as in Fig. 10A,B .... *Caiman latirostris*
    b) Ventral collar scales greatly enlarged, especially mid- ventrally, composed of a single row of scales, belly scales in 20-27 transverse rows 15

15. a) Flank scalation as in Figure 11 ..... *Caiman crocodilus yacare*
    b) Flank scalation as in Figure 12 ..... *Caiman crocodilus crocodilus*
    c) Flank scalation as in Figure 13 ..... *Caiman crocodilus fuscus*

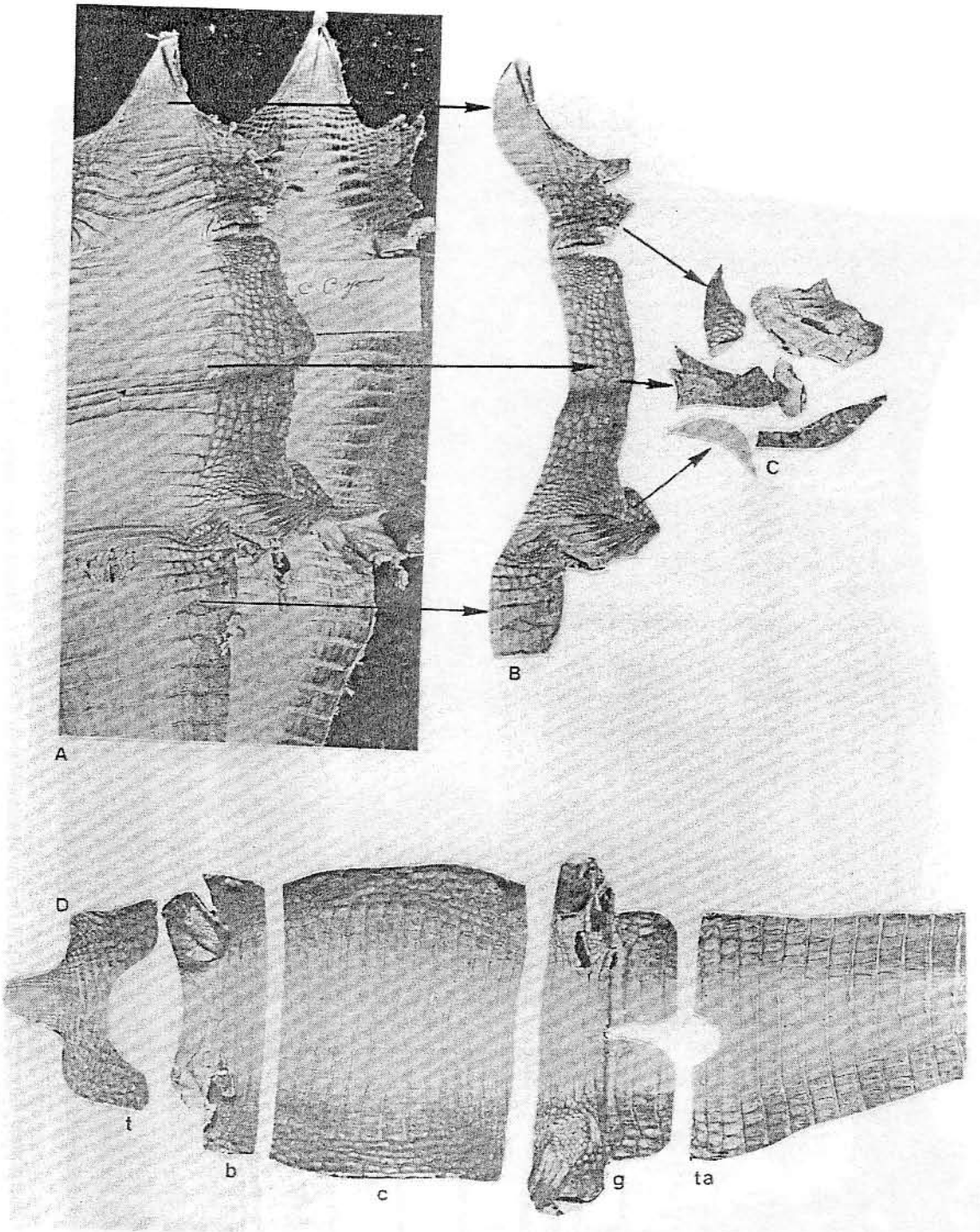


Figure 1. A. Full belly "crust" tanned skins of *Caiman crocodilus*. Crusts are partially tanned and are unfinished. The leather at this point is bleached white or tan and is softened. B. Flank skins are cut from the sides of crocodilians, usually caiman, and include portions of the upper front and rear legs,as well as the base of the tail and part of the lower jaw. C. Scraps or trimmings are pieces of finished or crust skin which remain after flanks or whole skins are cut up for manufacture into products. D. Black caiman skins are often cut up and sold as throats (t), bellies (c), girdles (g), and tails (ta).

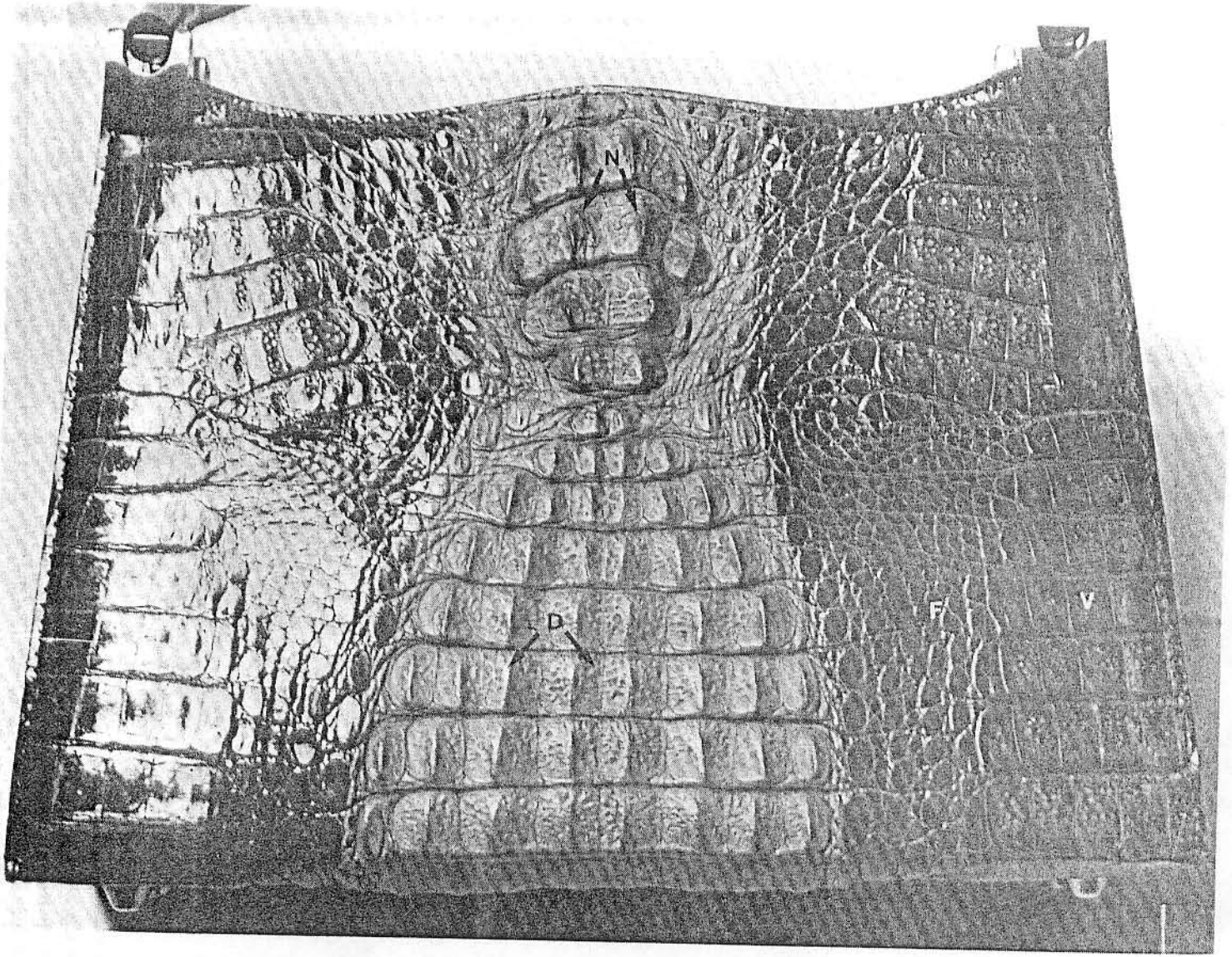


Figure 2. This is a "hornback" handbag manufactured in Thailand from *Caiman c. fuscus* skins shipped from South America, and exported or sold to tourists as native crocodile. The nuchal cluster (N), dorsal scales (D), pitted ventral scales (V), and flank (F) regions are shown.

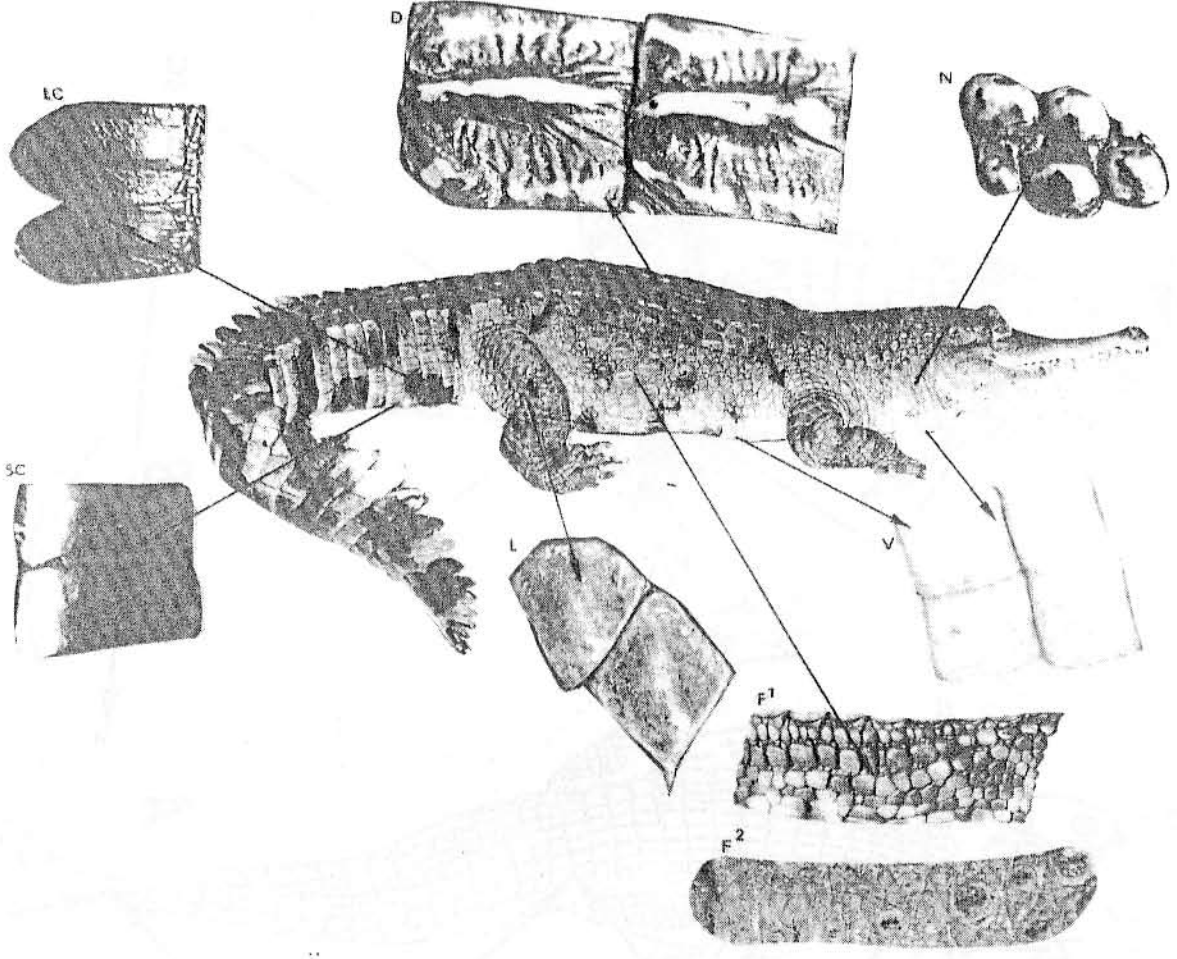


Figure 3. Characteristic scale shapes which are found on different body regions. D - Rectangular to square heavily ossified and strongly keeled dorsal scales. LC - Posteriorly rounded, ossified, keeled rectangular scales from the lateral tail regions. N - Round neck scales. SC - Rectangular unkeeled ventral tail scales. V - Unkeeled ventral scales. L - Diamond shaped scales on the dorsal regions of the legs. F - Arrows separated by the dotted line indicate the extent ofthe flank region from axilla to groin used to calculate approximate flank length relationship to total body length. Random large scales are shown in a field of smaller round scales. F^1 shows flank scales arranged in uniform rows. F^2 shows random scales in a field of soft creased skin.

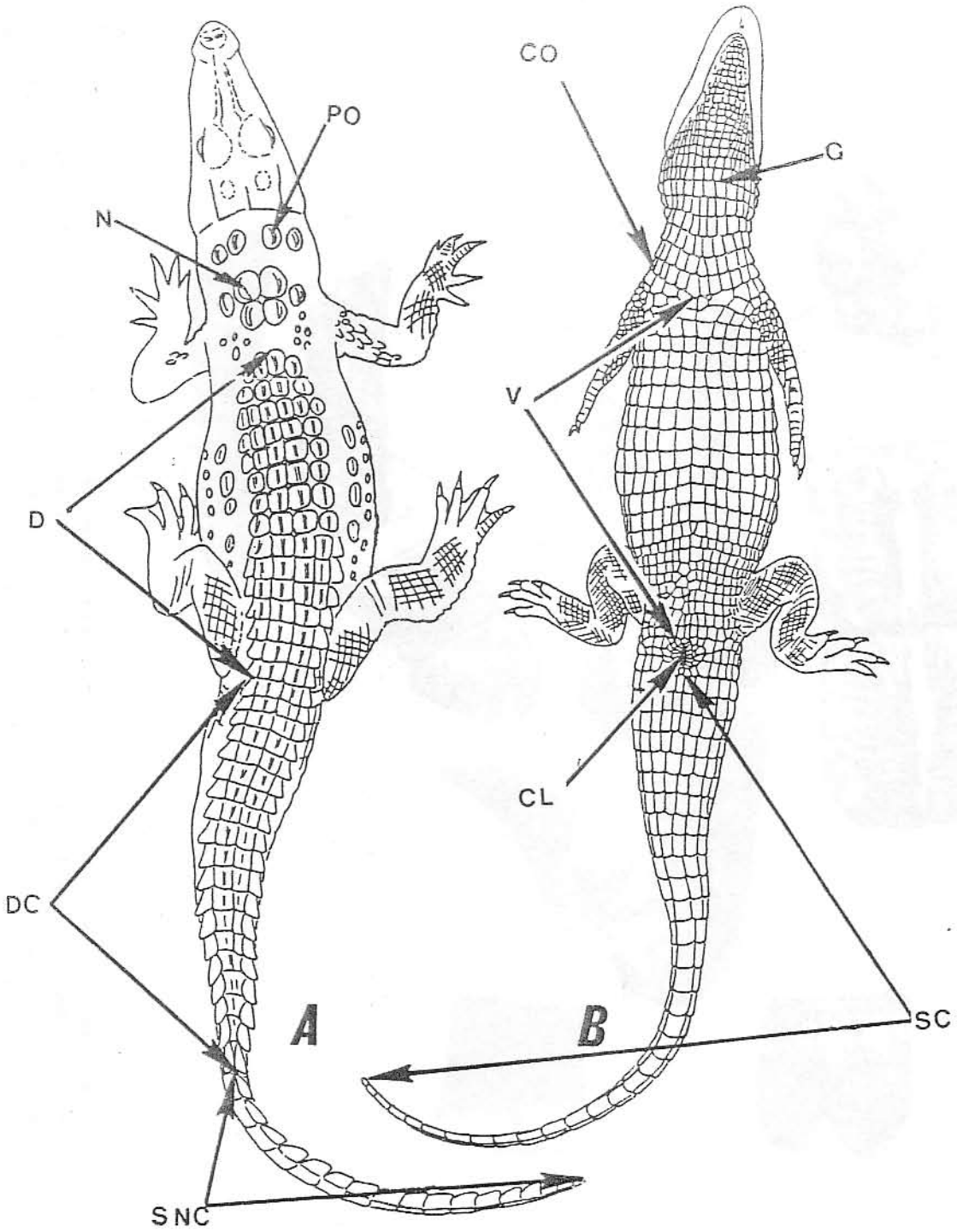
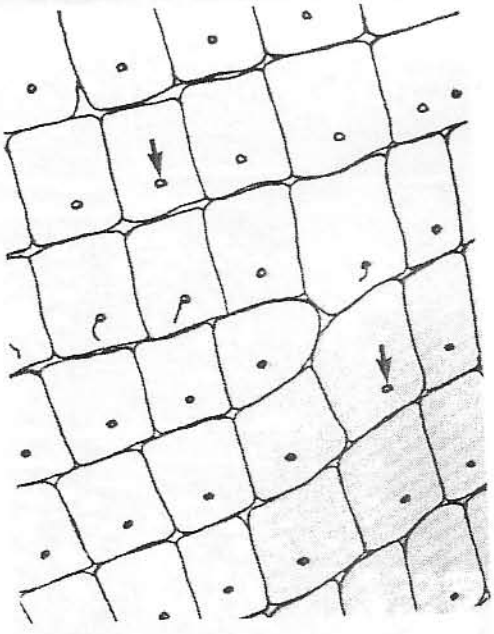
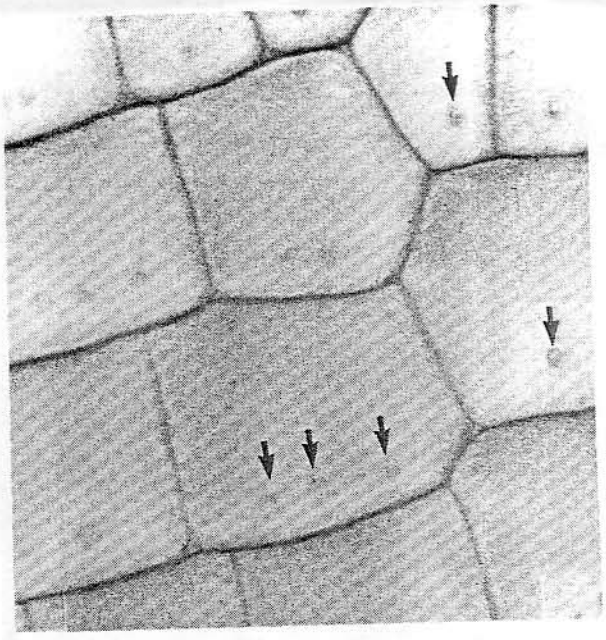


Figure 4. Body regions of crocodilians. A. SNC - single caudal verticils; DC - double caudal verticils; D - dorsal scales; N - nuchal scales; PO - post occipital scales.
B. SC - sub-caudal scales; CL - anal opening or vent; V - ventral scales; CO - collar; G - gular region.



A



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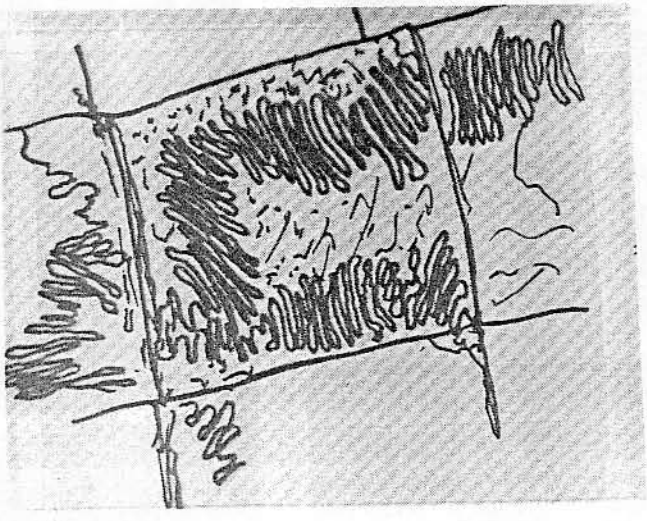

C

Figure 5. A. Arrows show integumentary sense organs (ISOs) found on the body scalation of members of the families Crocodylidae and Gavialidae. Ventral or belly scales are depicted diagrammatically. B. ISOs as seen in life and on hides and products. Multiple ISOs on ventral scales are not uncommon. Multiple ISOs are not diagnostic for any specific species. C. Undulating worm trail produced by the boring of a parasitic nematode (cappilaria) which may be seen on the ventral scales of many crocodilians from round the world.

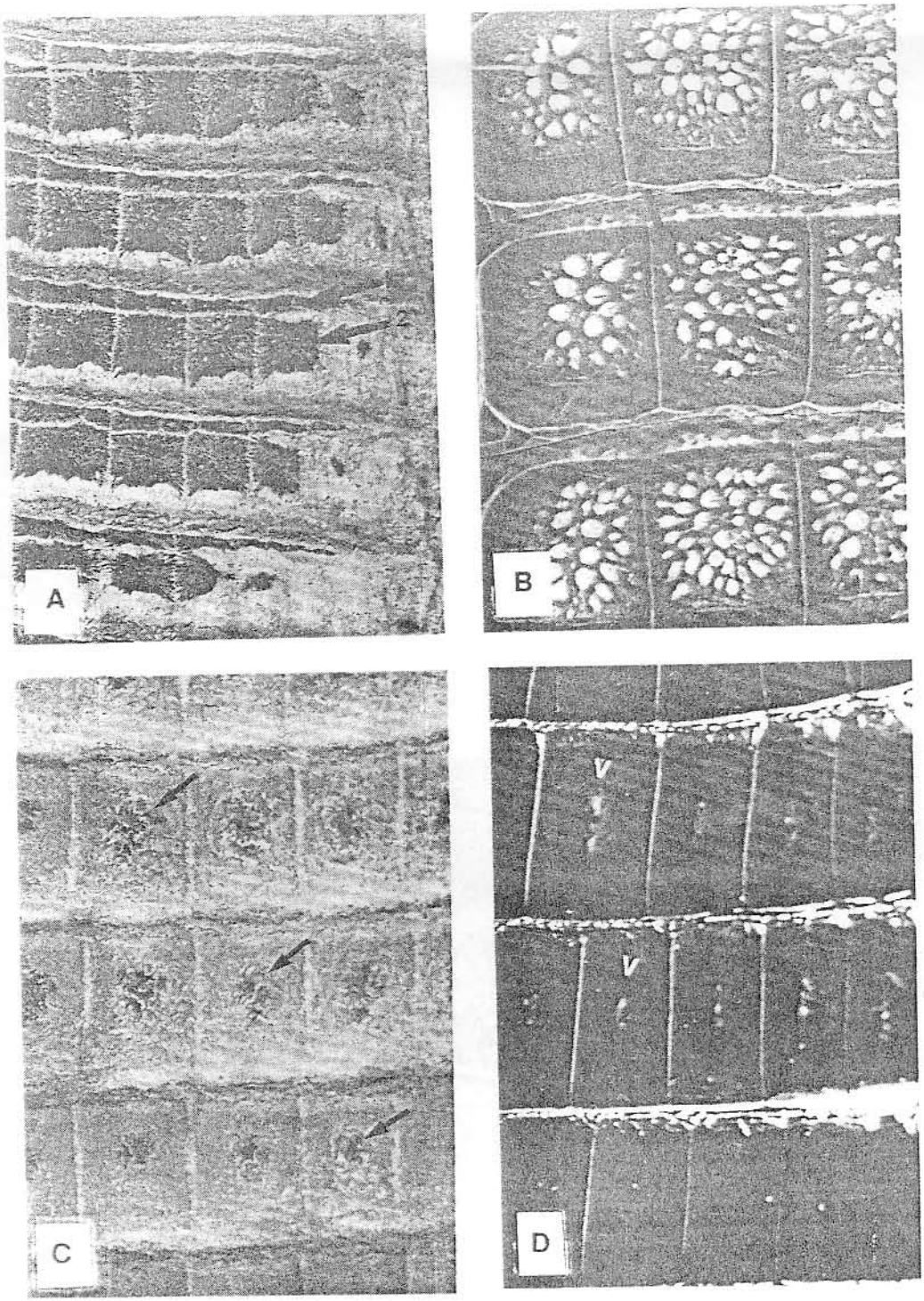

Figure 6. A. Arrows indicate composite two part ventral osteoderms typical for *Caiman* and *Melanosuchus* is viewed from the flesh side of a finished skin. B. Two part ventral osteoderms of *Caiman*. Arrows indicate surface pitting in the finished skin. C. Arrows indicate the large round osteoderms found in the belly scales of *Crocodylus cataphractus* as viewed from the flesh side of the finished skin. D. Large arrows indicate small elliptical belly osteoderms of *Crocodylus niloticus* as seen from the skin surface.

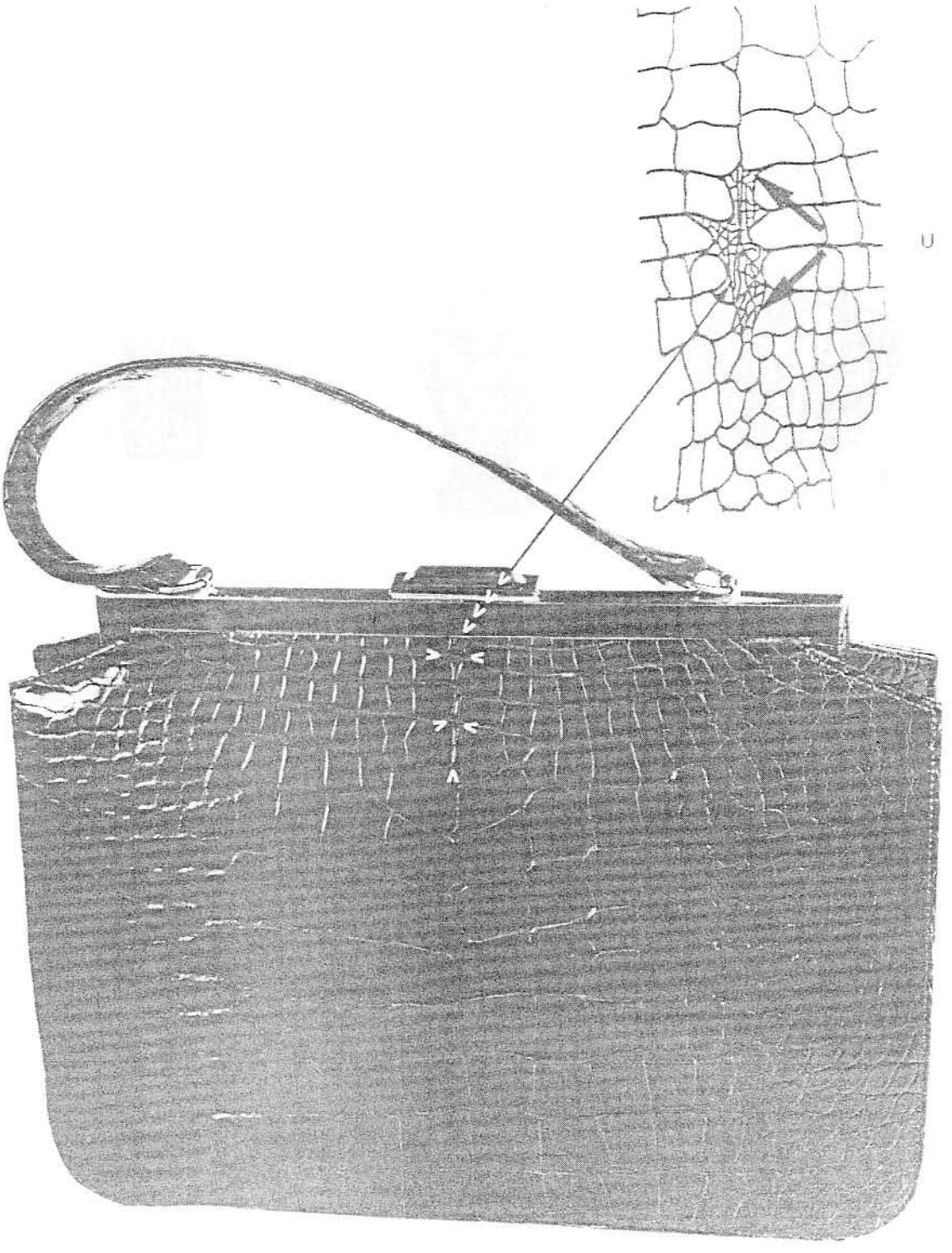

Figure 7. Arrows indicate the network of fine creases which remains as an umbilical scar (U) throughout the life of *Alligator mississippiensis*. The scar is usually seen near the top of the front panel of quality handbags made from this species. It is diagnostic in conjunction with the absence of ISOs.

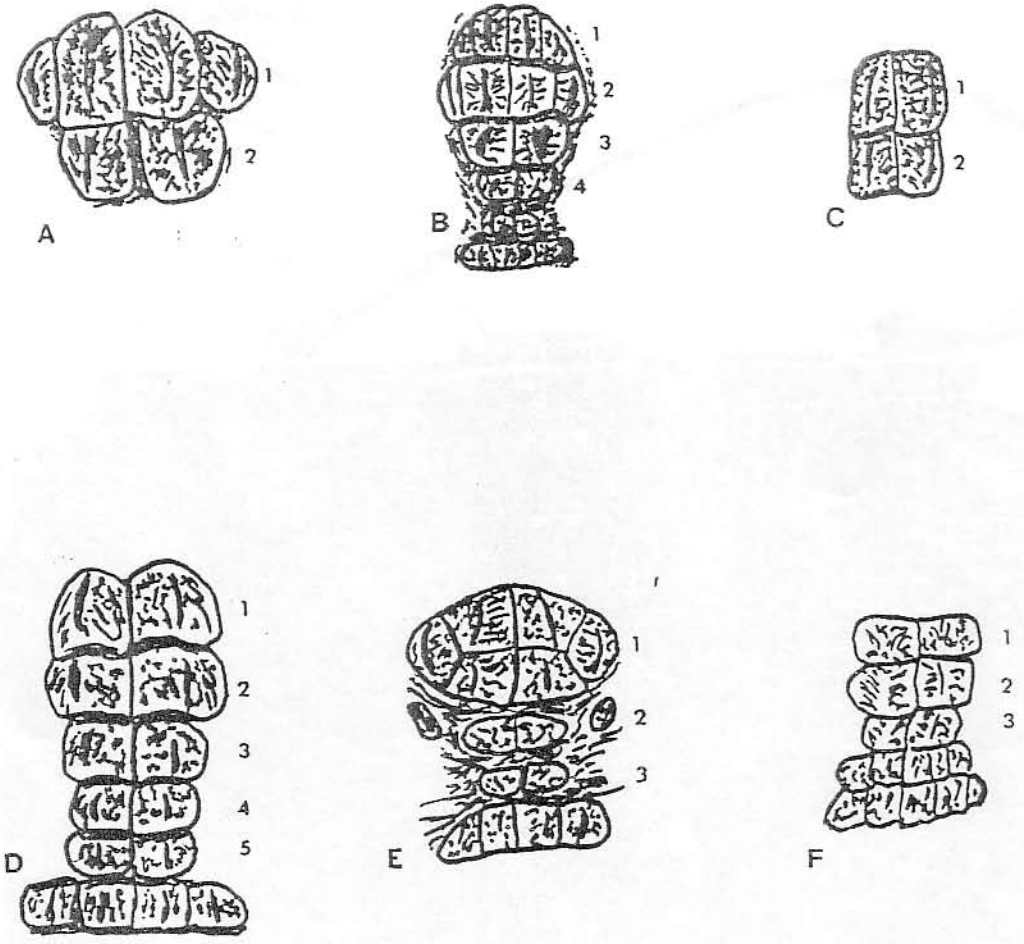

Figure 8. A. Nuchal cluster (See also Fig. 3.) typical for most *Crocodylus*. B. Nuchal cluster typical of *Caiman* and *Melanosuchus*. C. Nuchal group typical for *Osteolaemus tetraspis*. D. Nuchal group typical for *Tomistoma*. E. Nuchal group typical for *Crocodylus johnsoni*. Note the similarity of the anterior scales in the nuchal group to those in A; however, they are continuous with the dorsal scales and are tightly sutured together to form what appears to be one contiguous mass. F. Nuchal group typical of *Crocodylus cataphractus*.

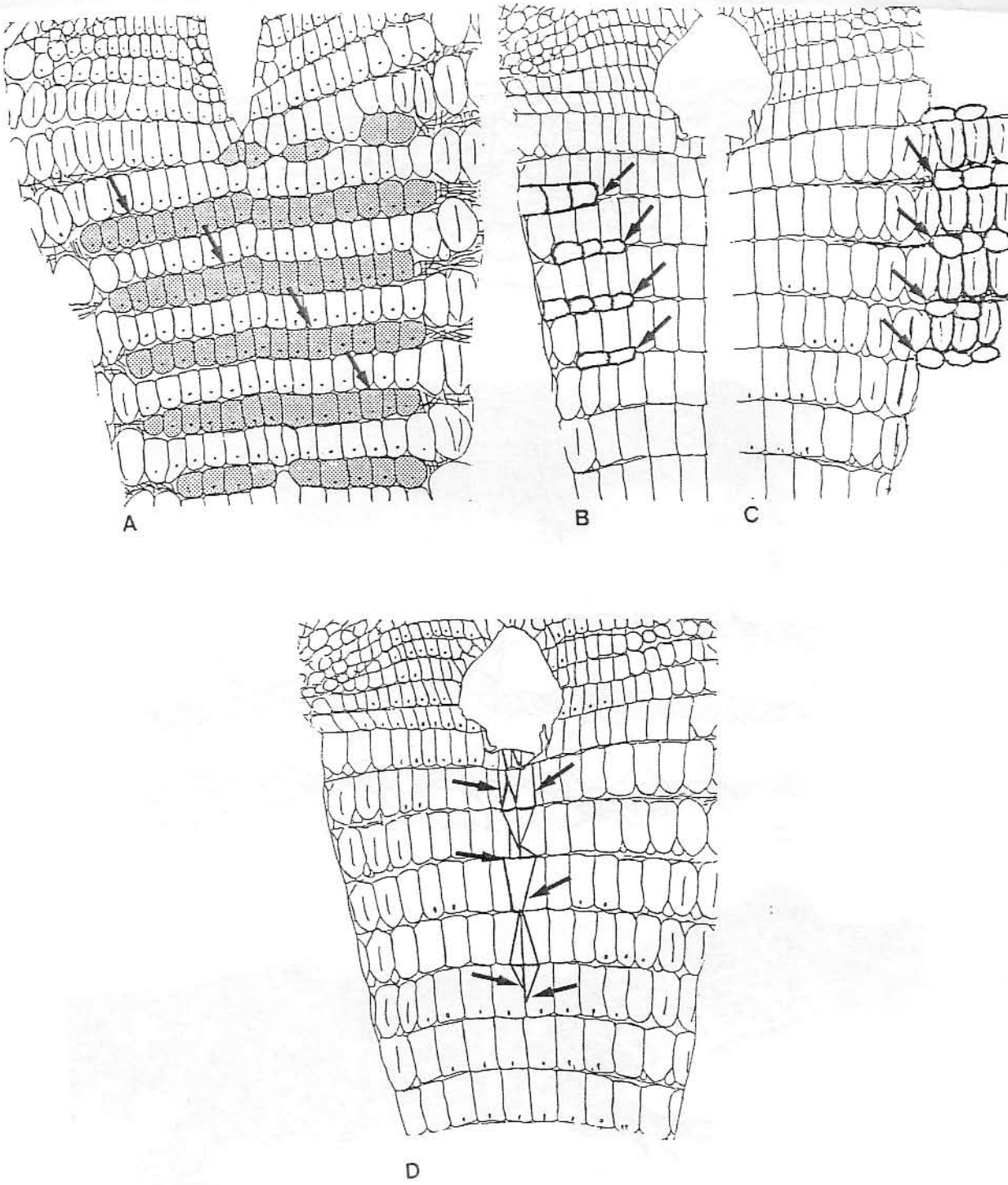

Figure 9. Subcaudal tail section immediately posterior to the vent showing inclusions of scales. A. In conjunction with ISOs, subcaudal tail inclusions are shown occupying the lateral and ventral portions of the anterior tail which is characteristic of *Crocodylus moreleti*. B. Tail inclusions typical for *Melanosuchus niger* which lacks ISOs. C. Inclusions which are confined to the lateral tail regions, typical for *Crocodylus acutus*. D. Midventral series of inclusions extending from the vent through the first several rows of scales are typical for *Crocodylus siamensis*.

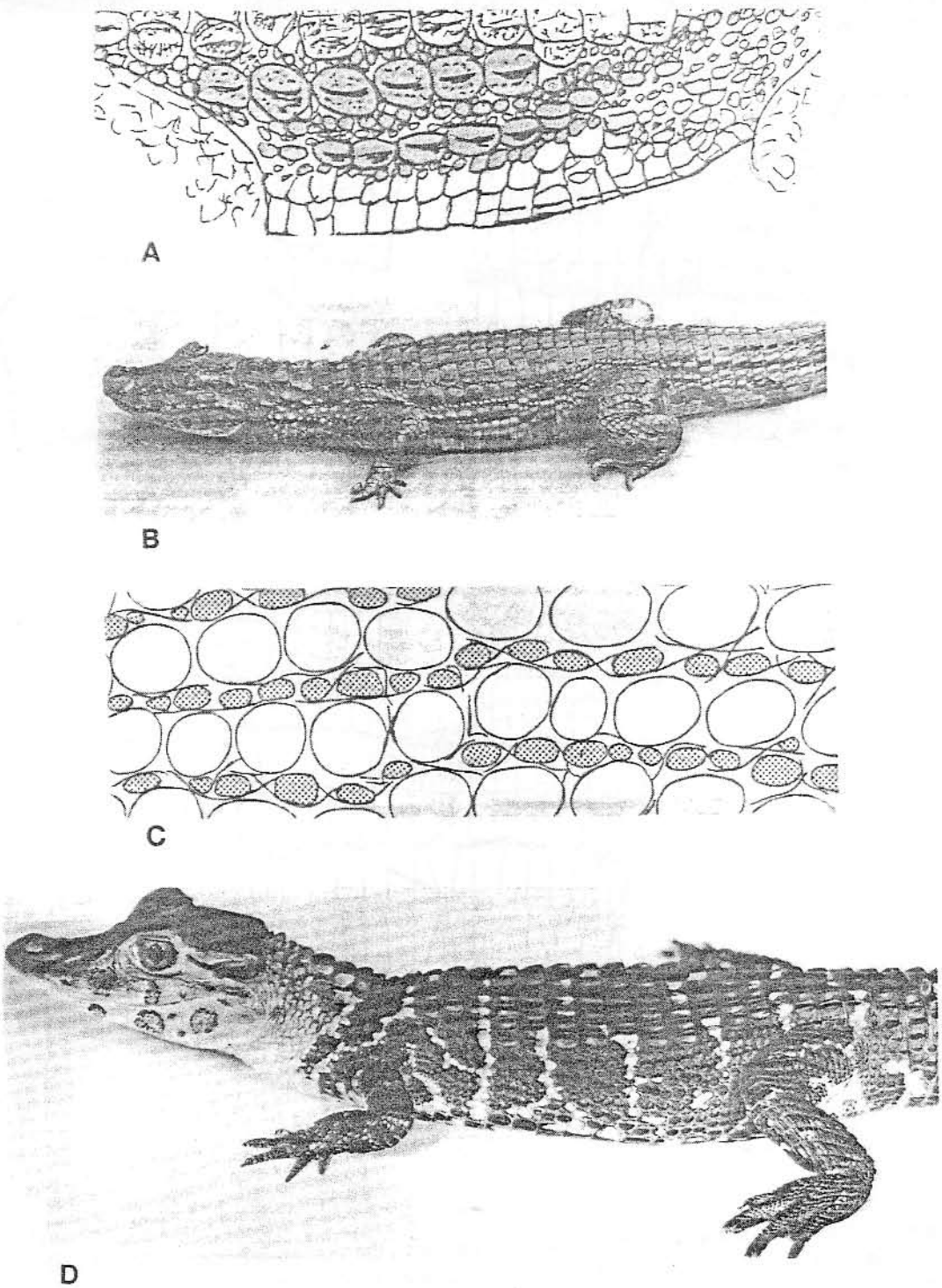

Figure 10. A and B. Flank scalation typical for *Caiman latirostris*: A. Illustrated. B. In life. C and D. Flank scalation typical for *Melanosuchus niger*, composed of at least five rows of alternating small and large round, poorly keeled scales. C. Note alternating rows of large and small scales illustrated. D. In life.

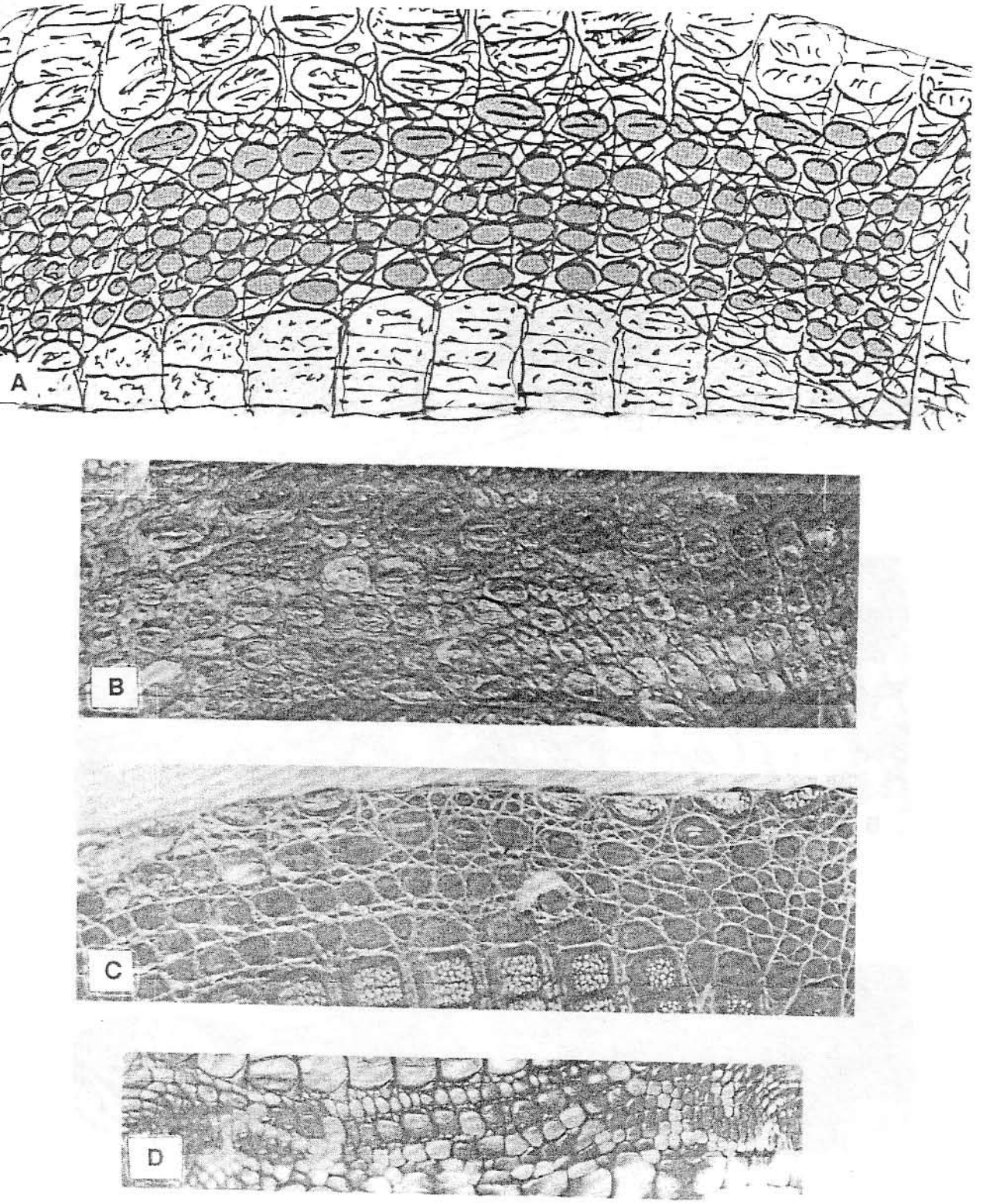

Figure 11. Flank scalation typical for *C. crocodilus yacare*. A. Diagrammatic. B. Raw dried skin. C. Tanned and finished skin. D. In life (juvenile).

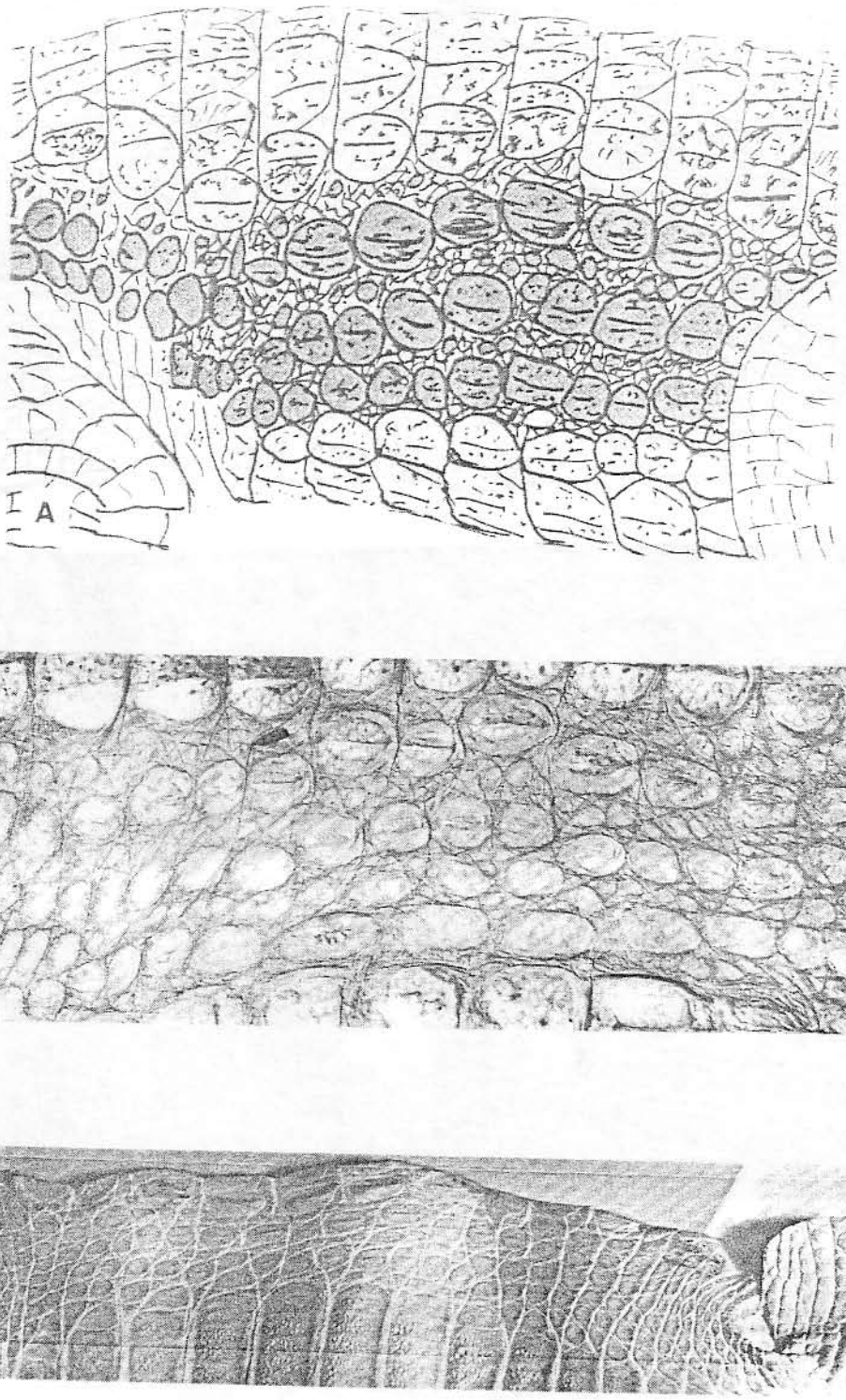

Figure 12. Flank scalation typical for *C. crocodilus crocodilus*. A. Diagrammatic. B. Raw dried skin. C. Crust tanned skin.

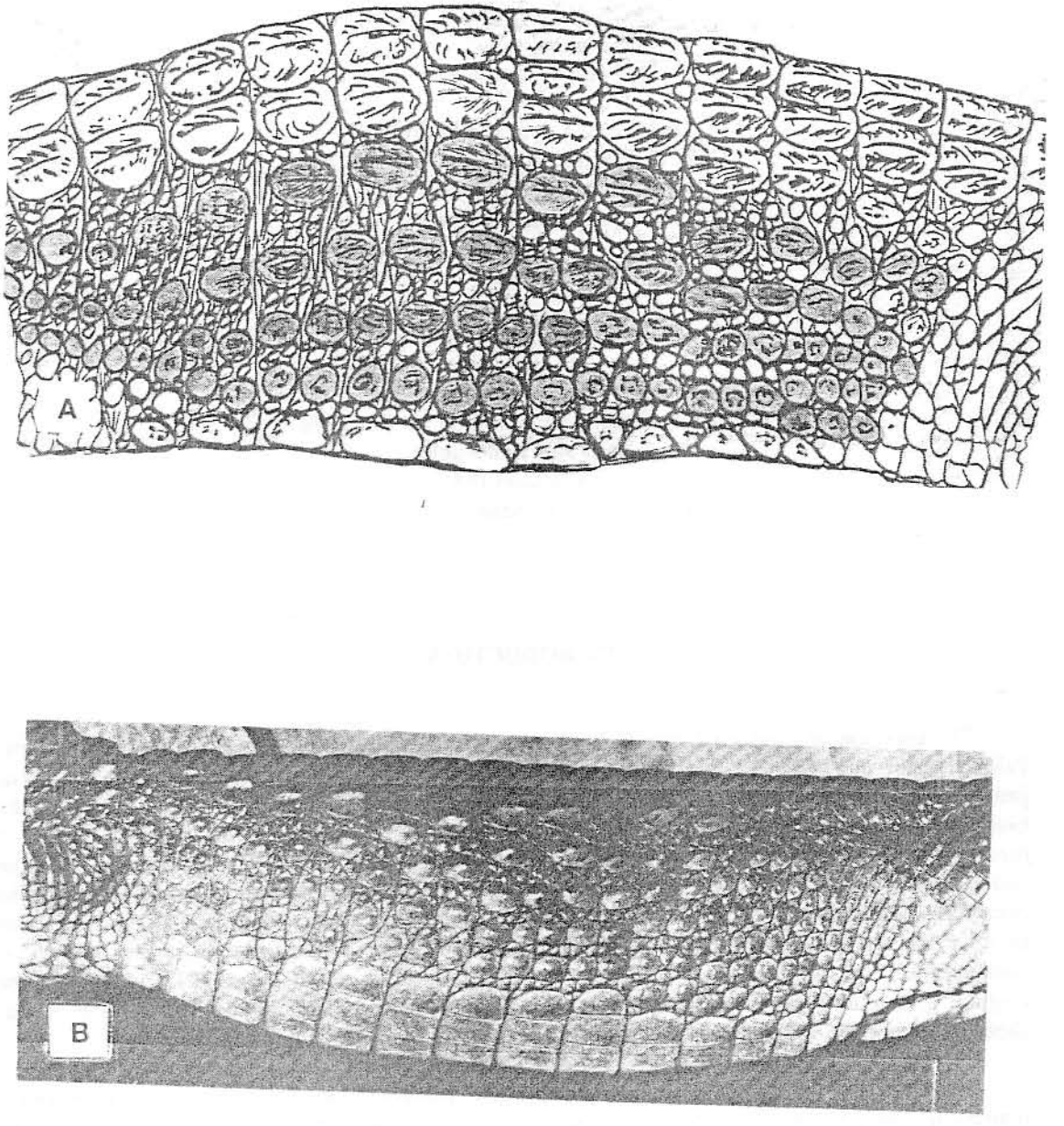

Figure 13. Flank scalation typical for *C. crocodilus fuscus*. A. Diagrammatic. B. As in life.