Right: In accordance with CITES guidelines, countries exporting crocodilian skins attach non-reusable tags to each one. Here, officials from the Louisiana Department of Wildlife and Fisheries inspect the tags on salted American Alligator (*Alligator mississippiensis*) skins. (Ted Joanen)

Although most crocodilian populations around the world have been reduced at some stage by hunting for skins, many conservation programmes are now exploiting the commercial value of crocodile skins as an economic incentive for crocodilian conservation. The leather made from "classic" crocodilian skins maintains a high lustre and is very durable. It is incorporated into some of the most expensive fashion accessories available.

Below: In Zimbabwe, farm raised Nile Crocodiles (*Crocodylus niloticus*) await skinning while the skin of one specimen is washed down to remove blood and any detritus. To obtain the highest market prices, great attention must be paid to the skinning, scraping and curing of skins. (Kevin Van Aarsveldt)

Centre Below: Saltwater crocodile (*Crocodylus porosus*) skins at the Edward River Crocodile Farm in Queensland, Australia, being inspected, resalted and rolled for storage. (Grahame Webb)

Below: In Louisiana, an annual harvest of American Alligators (*Alligator mississippiensis*) from the wild has been in operation for over a decade. Here, the rolled and salted skins are prepared for sale. (Ted Joanen)

Below: Fashion goods made from crocodilian skins on display in Singapore. (Grahame Webb)

Below: Saltwater crocodile (*Crocodylus porosus*) skins at the Edward River Crocodile Farm in Queensland, Australia, being inspected and resalted. (Grahame Webb)

Above: The first Australian crocodile farm was established as a commercial enterprise for the Aboriginal people of Edward River, in Queensland. Here a blood sample is being removed from a saltwater crocodile (*Crocodylus porosus*) before it is skinned for export. (Grahame Webb)

Above: Aboriginal women at Edward River Crocodile Farm do most of th skinning of saltwater crocodiles (*Crocodylus porosus*). (Grahame Webb)

Below: In Papua New Guinea, a commercially viable crocodile industry has been established for many years. Here a saltwater crocodile (*Crocodylus porosus*) is killed for skinning. (Grahame Webb)

The attitudes of indigen peoples to crocodili are often complex and q different from those other segments of socie Crocodilians are commo embodied into the culture a religions of native peopl while also being used for fo In Australia and Papua N Guinea today, indigen people play a vital role in crocodile indust

CHAPTER 38

The Identification of Crocodilian Skins and Products

Peter Brazaitis[1]

OF the 22 species of crocodilians generally recognized throughout the world, about 15 are utilized commercially by the exotic leather industry, largely for the manufacture of luxury accessories for men and women. The species which produce particularly fine, supple leathers have historically been overexploited by the industry, often to the point where they have become threatened with extinction. This has resulted in the enactment of protective wildlife regulations, at regional, national and international levels, aimed at excluding endangered species from trade. It has also resulted in the development of management programmes aimed initially at the conservation of the species concerned.

The effective application of endangered species regulations is often contingent upon the ability of management authorities, and their enforcement agencies, to determine the species identity of skins (or products made from them) circulating in world trade. This is by no means an easy task with crocodilians, largely because there is a limited amount of information, both scientific and popular to draw on (King and Brazaitis 1971; Brazaitis 1973; Fuchs 1974; Wermuth and Fuchs 1978).

This chapter examines the characteristics of crocodilian skins that can be used to identify the species from which they came, and provides a key which can be used for making species identifications from whole skins. It also addresses the problem of identifying species from small pieces of skin or "trimmings" from processed hides, or pieces already incorporated into a final manufactured product.

The problem of species identification with manufactured products is Herculean compared to that with whole skins, but considerable progress has been made. By defining the body regions from which different parts of skin used in a product have been derived, looking for key characteristics of the skin from those regions, a species identification from a small piece of skin can often be made.

For consistency, the taxonomy and common names used in this chapter are the same as those used by Bellairs and Groombridge in Chapters 1 and 2 respectively. Information on the distribution and conservation status of each species is discussed in Chapter 2.

TRADE IN CROCODILIAN SKINS

The trade in crocodilian skins amounts to some one and a half million skins annually, three-quarters of which are the lower quality skins of *Caiman crocodilus* from South America, mostly taken in violation of national wildlife regulations (Hemley and Caldwell 1986). The remainder are mostly "classic" skins, which are more desirable commercially, because they usually lack bony plates (osteoderms) in the scales of the belly region of the skin. "Classic" skins come from many of the true crocodiles (subfamily Crocodylinae) and from *Alligator mississippiensis* (American alligator), although the skins of *Melanosuchus niger* (black caiman) and *Caiman latirostris* (broad-snouted caiman) are frequently categorized as "classic".

Most of the world harvest of crocodilian skins is taken from wild populations endemic to poor or developing countries, that are least able to afford extensive protection and/or management programmes. At the same time, consuming countries and countries which import, export, tan skins and manufacture products, are frequently those which do not have endemic crocodilians. Such countries may be somewhat indifferent to the problems of protecting wild crocodilian populations in foreign countries, especially if it is at the expense of their own industries and thus economies. Nevertheless, the wildlife authorities of such countries may still bear the responsibility of enforcing national and international wildlife protection agreements and commitments, to which they are signatories.

Forensic Examinations

In the USA, wildlife and wildlife products may only enter or leave the country through designated major ports, which are staffed with agents and

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Pages 373-86 *in* WILDLIFE MANAGEMENT: CROCODILES AND ALLIGATORS ed by Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead. Surrey Beatty and Sons Pty Limited in association with the Conservation Commission of the Northern Territory.

inspectors of the U.S. Fish and Wildlife Service. Manifests, invoices and customs declarations involving wildlife are referred to Wildlife Inspectors who may then personally examine the items described. Inadequate or improper documentation, discrepencies between the native land and the listed origin of the species invoiced, or the inclusion of a species which may easily be confounded with an endangered species, may result in the shipment being either refused entry or seized for further examination. Sample items may then be taken to an independent forensic examiner with expertise in making positive species identifications.

Within the USA, forensic examiners are deprived of any knowledge of the origins of the items in question, and may not be informed of the identity of the shipper or importer. Identifications must be made objectively, solely on the physical evidence. If the identification confirms the identity of the species listed and documentation is in order, and that species is not a prohibited one, the items are returned and "cleared" for import or export. However, if a violation is determined, the shipment is seized and the circumstances are referred to the office of the U.S. Solicitor for possible prosecution. The forensic examiner may then be called upon to re-examine all of the items in the shipment and may later testify about his or her findings in legal proceedings. Violations may be processed under civil proceedings or as felony violations, depending on the circumstances of the case.

Products in Trade

Crocodilian products commonly found in trade include dried or tanned trophy skins and skulls, raw salted or dried unprocessed skins, "crusts" (partially processed skins), tanned and finished skins, manufactured products, novelties and curios. Skins, whether they are raw, crusts or completely tanned and finished, may be presented whole, cut into specific pieces, or as "scraps" or trimmings left over from the manufacture of products. While whole skins are usually sold by the "piece", cut sections are often sold by the square measure and trimmings may be sold by the kilogram. Each form presents its own problems and limitations for species identification.

Manufactured products such as handbags, shoes, belts, wallets, watchbands and curios make up a large proportion of the total trade in crocodilian skins. Shifts in trade may reflect changes in the availability of raw materials, changing fashion trends and marketing targets, or the change in relative strengths of different currencies. Trained wildlife authorities who are accustomed to examining raw skins coming into the U.S. for manufacture into products, may suddenly find the imports have changed to manufactured products, coming from countries where manufacturing costs are lower than in the USA.

The low quality skins of *Caiman crocodilus* (South American or spectacled caiman) are often imported into South Africa and Southeast Asia for manufacture into cheap "crocodile" skin products. These are sold to tourists in local curio shops and are also exported to second-class gift shops in foreign countries, where they are frequently sold as "bargain-priced", quality, crocodile skin goods. At the same time, the skins of a high quality endemic species may be exported to fashionable, high-paying markets, such as exist in Europe and the USA.

Manufactured products may be composed of the skin of a single animal and species, or the skins of several animals of the same or different species. Products may also contain crocodilian skin in conjunction with domestic leathers, or with the skins of lizards, snakes and sea turtles. In general, "classic" skins of adult crocodilians are used as large pieces on larger manufactured products whenever possible. Poorer quality skins and trimmings are cut into smaller pieces for smaller products or "pieced-together" applications.

Native crafted goods are generally composed of poorly tanned skins, which lack the soft, supple quality of European manufacture. Seams and borders may be secured by thong wrapping, and the dye colouring is frequently unevenly distributed and blotchy. Handbags, attache cases and other products native crafted in West Africa [relying heavily on the skins of *Osteolaemus tetraspis* (West African dwarf crocodile), *Crocodylus niloticus* (Nile crocodile) and *Crocodylus cataphractus* (West African slender-snouted crocodile)] fall into this category. Similar products are manufactured and exported from Mexico, Central America and Southeast Asia. Many are so poorly crafted that it can be argued that they are an inexcusable waste of the crocodilian natural resource.

In contrast, handbags and other products of high quality European manufacture are usually made from matched panels of selected belly skins. Gussets and bottom panels may be made from sections of the tail, neck or leg skin (Fig. 1). These products may have a very glossy finish or a suede-like sauvage finish. Product linings include fine fabrics or soft domestic leathers. Hinges and clasps may be made from brass or goldplate. The skins most often used for such high quality products are those of *Alligator mississippiensis* (American alligator); *Melanosuchus niger* (black caiman); *Crocodylus niloticus* (Nile crocodile); *Crocodylus porosus* (saltwater crocodile); *Crocodylus novaeguineae* (New Guinea freshwater crocodile); *Crocodylus moreletii* (Morelet's crocodile); and, *Crocodylus siamensis* (Siamese crocodile).

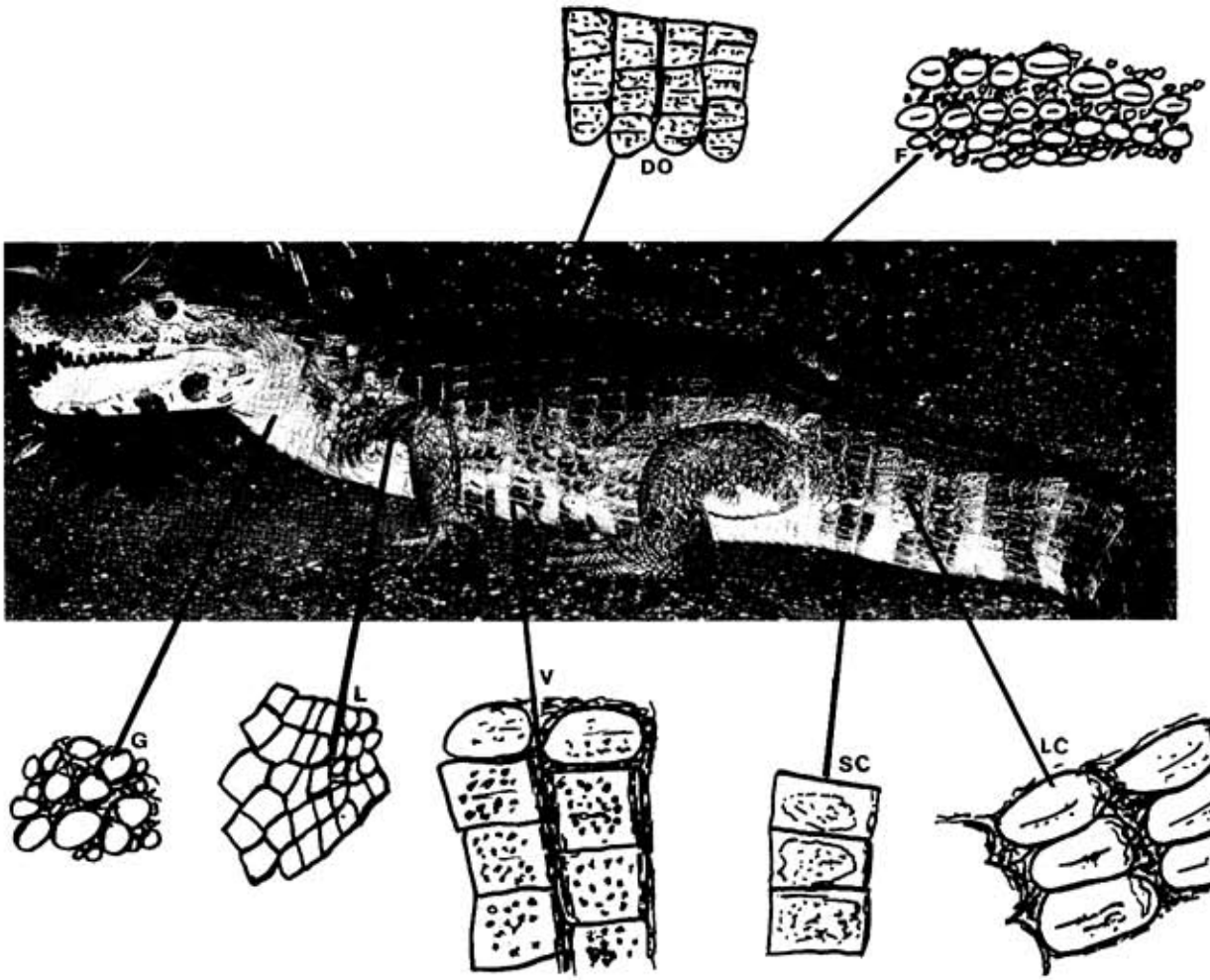


Fig. 1. Characteristic scale shapes found on different body regions of crocodilians: DO, dorsal scales are square or rectangular in shape, are nearly entirely ossified, and usually bear a well developed keel; F, flank skin may be composed of finely creased, soft skin, bearing a few randomly distributed round or oval scales, or it can be composed of oval, round or rectangular scales, which may be keeled or unkeeled, and which may be in regular or irregular rows; G, round or oval scales on the sides of the throat or neck (gular region); L, diamond-shaped scales on the legs, usually arranged in oblique rows; LC, caudal scales of the lateral portions of the tail are rectangular in shape, are posteriorly rounded, and generally have a distinct longitudinal keel; SC, sub-caudal scales are rectangular in shape and are not keeled; V, ventral scales are generally square along the ventral midline and run in transverse rows, ending in a scale with a somewhat oval shape (species = *Caiman crocodilus*).

Handbags manufactured in Southeast Asia are frequently made of poorly tanned skins which are barely flexible. In addition, many feature the "hornback" appearance, in which the front and rear panels of the bag display the scalation of the dorsal surface of the neck, back and tail of the animal. The "hornback" area on the product is usually left unglazed, in contrast to the lateral portions, which include the skin of the flanks and ventral surfaces of the animal, which are glazed. Species most often utilized in this type of product are: *Caiman crocodilus* (South American caiman) (Fig. 2); *Crocodylus porosus* (saltwater crocodile); *Crocodylus johnstoni* (Australian freshwater crocodile); and, *Tomistoma schlegelii* (Malayan false gavial).

Shoes vary greatly in quality, type of manufacture and species utilized. Quality European-made shoes frequently have toe and heel sections made from belly panels of juvenile or relatively small-scaled, subadult animals. Straps and buckles are made from throat, leg and neck regions. Sides may be made from domestic leather or entirely from crocodilian belly and tail sections.

Although classic skins are used in the manufacture of the best quality shoes, in recent years they have been manufactured from flank, throat and upper leg sections of *Caiman crocodilus* (Fig. 3). For this purpose, pieces are cut from flank skins already tanned, and are shipped from Colombia, Venezuela, Bolivia, Paraguay and Panama. The skins from various subspecies and races of *Caiman crocodilus*, and sometimes from other species, may be mixed in such shipments, and can be nearly indistinguishable from each other. The highest quality *Caiman* shoes are manufactured from the wider flanks of *Caiman crocodilus yacare*, which although tanned in Bolivia, may be taken largely from populations in Brazil, in violation of Brazilian wildlife regulations.

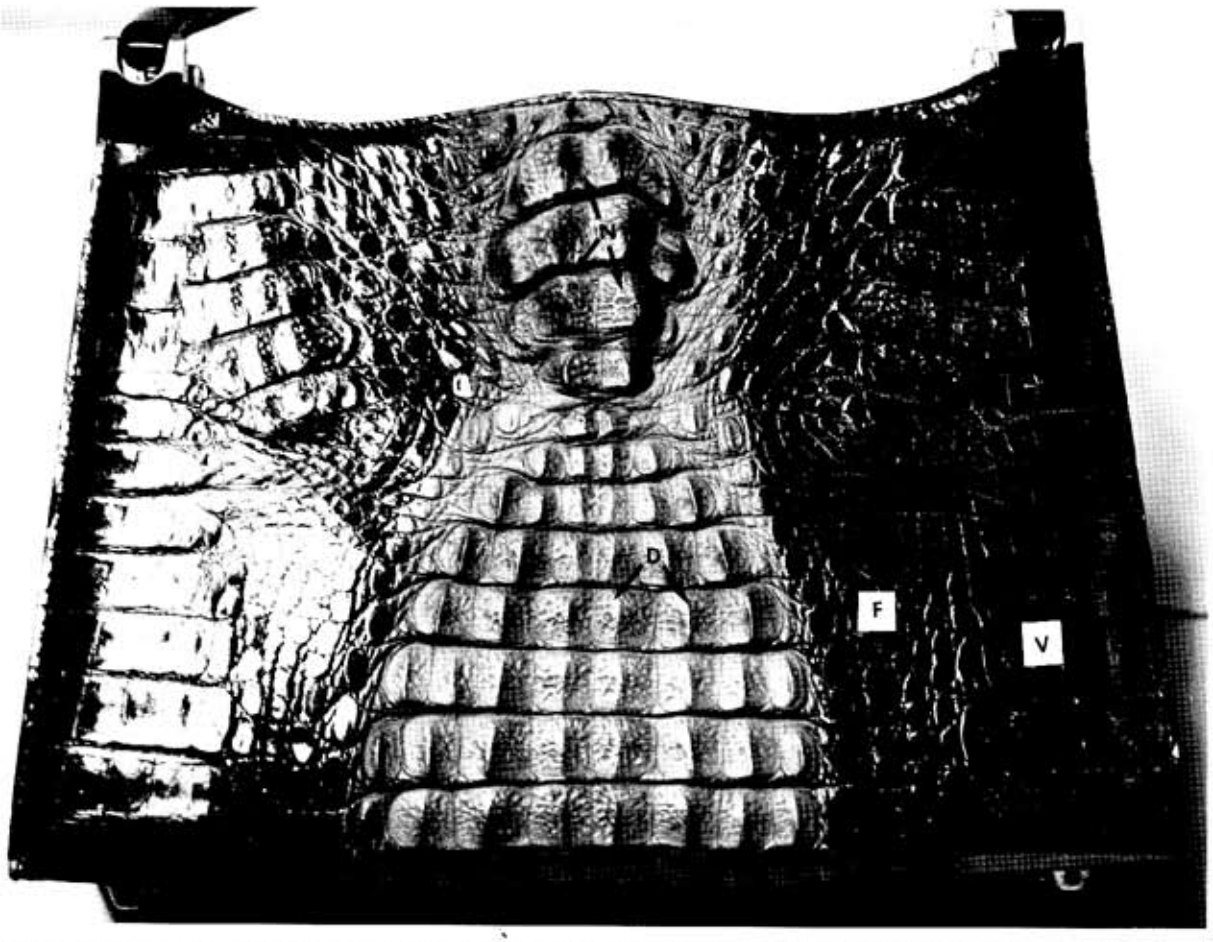


Fig. 2. A "hornback" ladies handbag from Thailand, made from *Caiman c. fuscus* skin. The animal probably orginated in Colombia, with tanning and bag manufactured in Thailand; it was sold as native "crocodile". Body regions shown are: D, dorsal scales; F, flank; N, nuchal cluster; and V, pitted ventral scales.

Poor quality shoes are made from crocodilian skins which have been vegetable tanned by native craftsmen. These skins accept dye so poorly that the manufactured shoes are left in neutral tones of tan, black or are dyed a maroon colour.

Quality wallets and billfolds are usually made from the skin of the throat, neck and flank regions of *Melanosuchus niger* (black caiman), *Alligator mississippiensis* (American alligator), and of the true crocodiles. Juvenile *Caiman crocodilus* (South American caiman) skins may also be used, in which case two or four belly skins, of yearling-sized caiman, may be utilized in a single wallet or billfold.

Except for native crafts, belts rarely contain long cut lengths of large-scaled belly skin. Most belts are made from a multitude of carefully matched pieces of trimmings or scrap skin, which are glued and sewn onto a high quality domestic leather backing. Watchbands are made entirely from trimmings of nearly any species.

In general, manufacturers may pay little attention to the biological identity or population status of the species whose skins they are utilizing. Crocodilian leathers are selected on the basis of aesthetic appearance, continued availability, cost of the raw material and the current "look" in fashion — which is itself created on the basis of cost and availability of raw materials. Fashion advertisements or product labels rarely accurately identify the species from which the product is made, and all too often use meaningless commercial terms which ensure the average consumer and merchandiser will remain ignorant buyers, paying the highest prices.

Skins and products are shipped around the world, combined with other skins and products from various sources, and are reshipped again. Some producer countries have introduced tagging and marking of skins to control the exploitation of their resources, but the tanning industry has resisted tagging techniques which substantiate the origin and identification of individual skins in trade. *Alligator mississippiensis* (American alligator) is the only species in which skins in trade bear a numbered tag that must remain affixed to the skin from harvest until the hide is manufactured into a product.

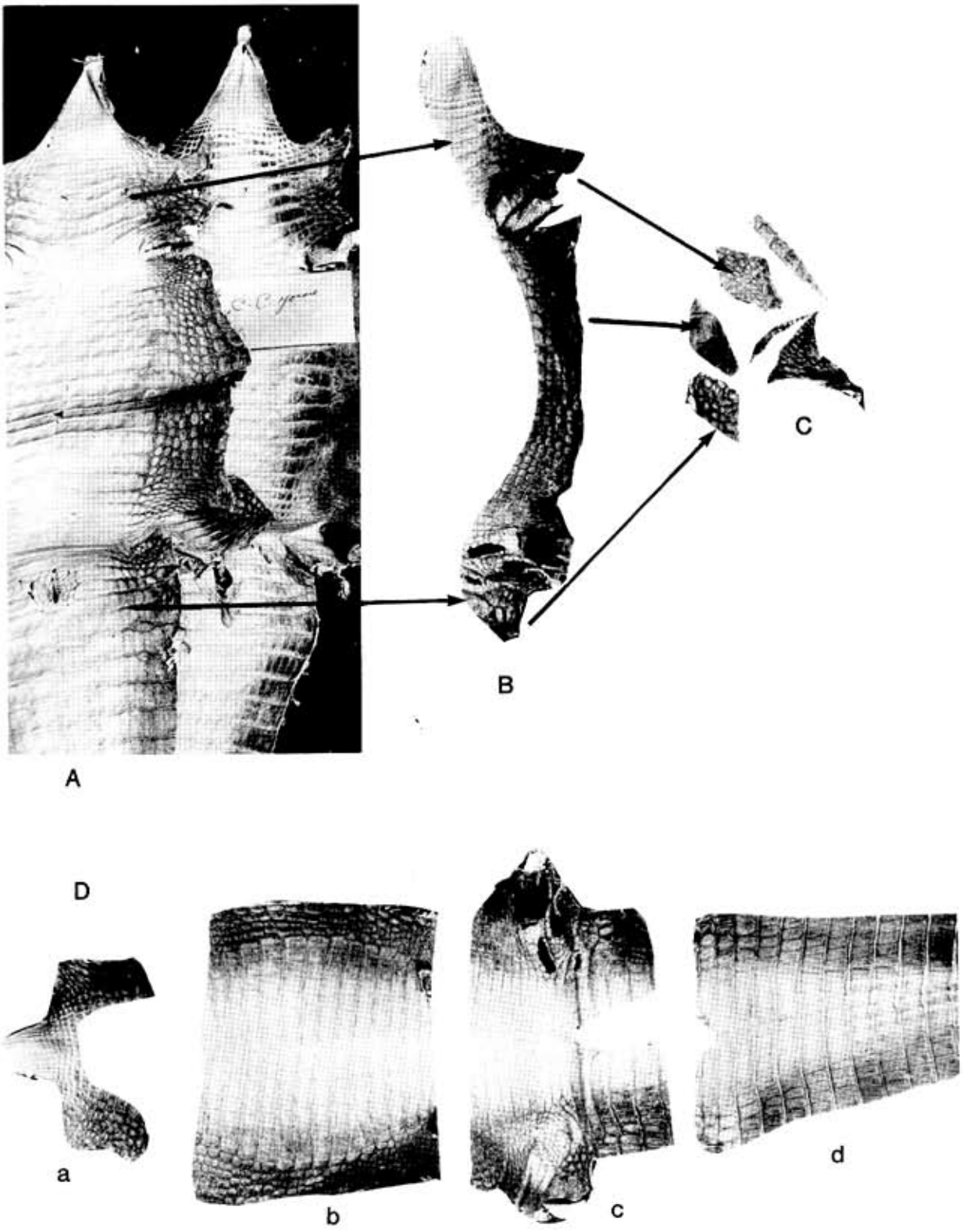
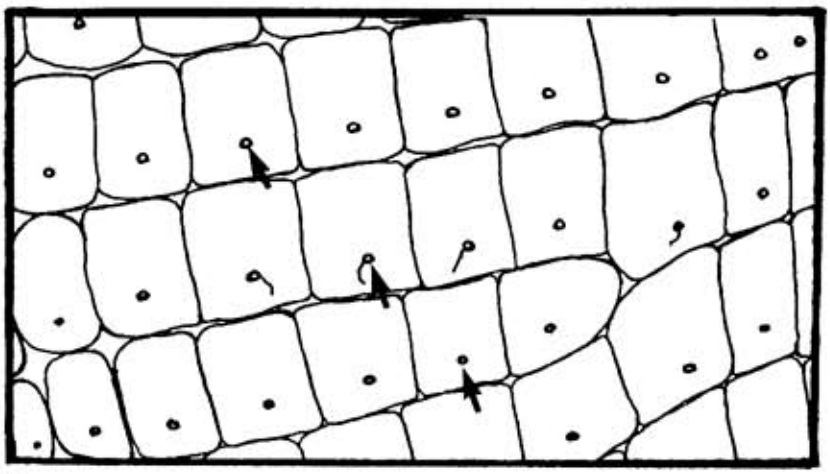


Fig. 3. A. Full belly "crust" skins of *Caiman crocodilus*. Crusts are partially tanned and unfinished, somewhat soft leather; B. Flank skins are cut from the side of the animal and include a front and rear leg segment, the base of the tail and sometimes the skin of the lower jaw. Flanks are sometimes the only piece of skin taken from a *Caiman*; C. Scraps or trimmings are pieces of finished skin which remain after flanks or whole skins are cut for manufacture into products. D. Skins of some species (*Melanosuchus niger*) are often cut and sold as: throats (a), bellies (b), girdles (c), and tails (d). The section between the throat and the belly is sometimes sold as a "collar", which is similar to a girdle.



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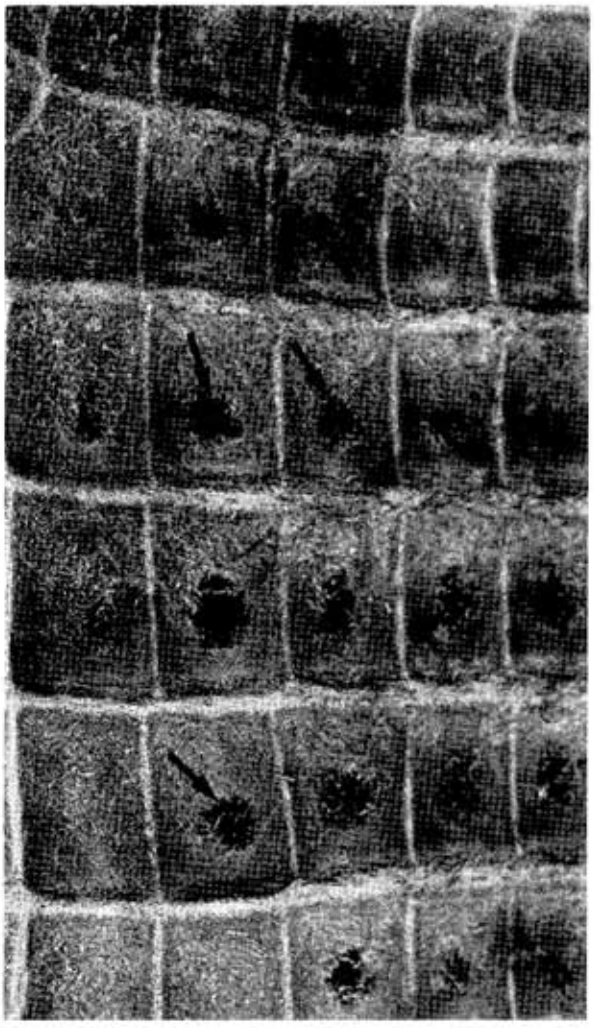

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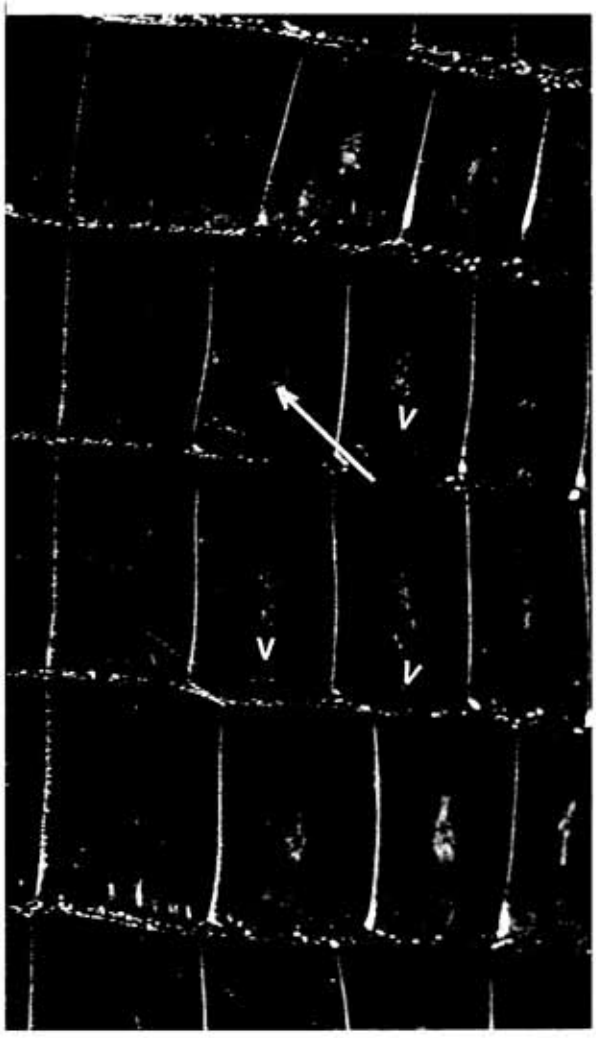


C

Fig. 4. A. Arrows indicate integumentary sense organs (ISO), which are found on the body scalation of members of the subfamilies Crocodylinae and Gavialinae (ventral or "belly" scales are depicted). B. Arrows indicate the large round osteoderms found in the belly scales of *Crocodylus cataphractus* as viewed from the flesh side of the finished skin. C. Arrow indicates small elliptical osteoderm in a ventral scale of *Crocodylus niloticus* (as seen from the skin surface), and V's the ISO's. (Adapted from King and Brazaitis 1971).

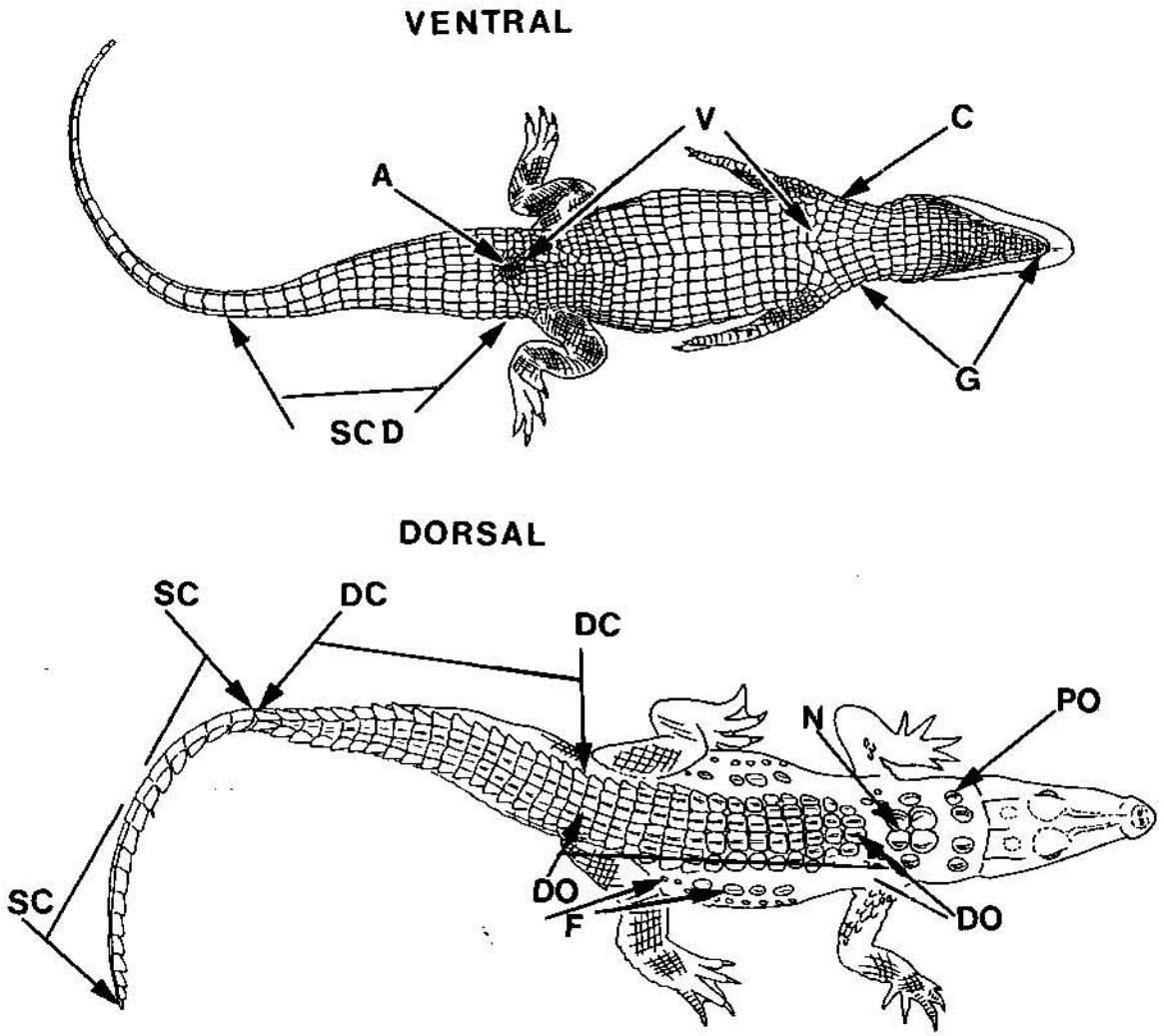


Fig. 5. Body regions of crocodilians as seen from dorsal and ventral surfaces: A, anal opening or vent; C, collar; DC, double caudal verticils; DO, dorsal scales; F, flanks; G, gular region; N, nuchal scales; PO, post-occipital scales; SC, single caudal verticils; SCD, sub-caudal scales; V, ventral scales. (Adapted from King and Brazaitis 1971).

SPECIES IDENTIFICATION OF SKINS AND PRODUCTS

The identification of hides and products is still in its infancy and relies heavily on gross morphological characteristics. For example, the numbers of ventral scale rows, the inclusions of small groups of scales between rows of scales on certain regions of the tail, and the shape and arrangement of scales from certain regions of the body, can all be definitive, either as individual characteristics or when viewed in conjunction with other features.

The skins of species from the subfamilies Crocodylinae and Gavialinae can be separated from those of the subfamily Alligatorinae on the basis of *integumentary sense organs* (ISO), which are sometimes called follicle glands or follicle pits. ISO's are completely absent from the body scales of all members of the subfamily Alligatorinae, but are present on members of the subfamilies Crocodylinae and Gavialinae; typically on the posterior portion of nearly all body scales. ISO's are most clearly seen on the belly scales (Fig. 4), where there is usually one per scale, but occasionally two and three.

When identifying species from products, it is important to identify the body region (Fig. 5) from which the piece of skin has been derived. This is usually done on the basis of regional scale shapes and patterns (Fig. 1). When specific characteristics of those patterns are examined, it is often possible to make a species identification or reject one that has been offered.

Identifying Characteristics of Skins Commonly Used in the Manufacture of Products

Among the true crocodiles, which all bear ISO's on the body scales, *Osteolaemus tetraspis* (African dwarf crocodile) can usually be identified fairly easily. Its skins are often used in the manufacture of poor quality native crafts, particularly handbags and cases. It is distinguishable by its flanks, which appear to have large, keeled scales somewhat randomly

Fig. 6. Enhanced photograph of West African native crafted "hornback" handbag made from *Osteolaemus tetraspis* skin, and showing diagnostic features: D, dorsal scales; N, square nuchal cluster; R, random scales on the creased skin of the flank regions, on either side of the dorsal scales.

distributed within a sea of creased skin (Fig. 6). The characteristic nuchal cluster on the back of the neck is composed of a square of "block" like scales, and there are around 18 to 22 transverse rows of scales on the ventral surface. The scales of the belly skin are heavily ossified, and is not easily dyed, shaved thin or decalcified in tanning. Items appear bleached or tan in colour, and lack natural markings and pigment; they are stiff and unyielding. Native crafts made from this species usually include the diagnostic nuchal cluster and the flank regions, as seen on Fig. 6.

Crocodylus niloticus (Nile crocodile) and *Crocodylus cataphractus* (West African slender-snouted crocodile) both occur frequently in trade, and both have ISO's. *Crocodylus niloticus* skins may have no bony osteoderms, but on occasion have some. If so, they are poorly-developed, small, elliptical osteoderms restricted to the gular and pectoral regions of the skin — this distribution of osteoderms can be diagnostic. In contrast, the skins of *C. cataphractus* have extensive, poorly-developed, round osteoderms in nearly all of the ventral scales. These can be clearly seen as flattened hard reflections under the surface of the glossy smooth scales in quality items (Fig. 4B, C), and as hard, pronounced bony plates on native crafts.

The skin of *Crocodylus siamensis* (Siamese crocodile) lacks ventral osteoderms and has ISO's. However, the mid-ventral row of irregular scales, extending onto the tail from the cloaca, is diagnostic (Fig. 7B). Furthermore, this part of the tail skin is usually included in products made from the species. In quality handbags it can usually be seen by close examination of the part of the skin used in the base and gusset portions of the product.

These same regions of handbags and cases, and the skin used on shoes, should also be examined for inclusions of extra scales between the rows of scales on the ventral, anterior portion of the tail. In conjunction with ISO's, these are diagnostic for other species of crocodilians, although their exact disposition is important.

If ISO's are present and the inclusions occupy the ventral portions of the tail, between the ventral rows of scales on the tail (Fig. 7A), the species is *Crocodylus moreletii* (Morelet's crocodile). However, if the inclusions are found on the sides of the tail, rather than on the ventral or mid-ventral regions, it is *Crocodylus acutus* (American crocodile) (Ross and Franklin 1974). Ventral tail inclusions (Fig. 7A) without the presence of ISO's is diagnostic for *Melanosuchus niger* (black caiman). Knowing the configuration of scales from each part of a crocodilian's body (Figs 1 and 5) is essential for making accurate determinations.

"Squiggles" (Fig. 8A) on the scales of a skin were once thought to be characteristic of *Crocodylus intermedius* (Orinoco crocodile), but they are now

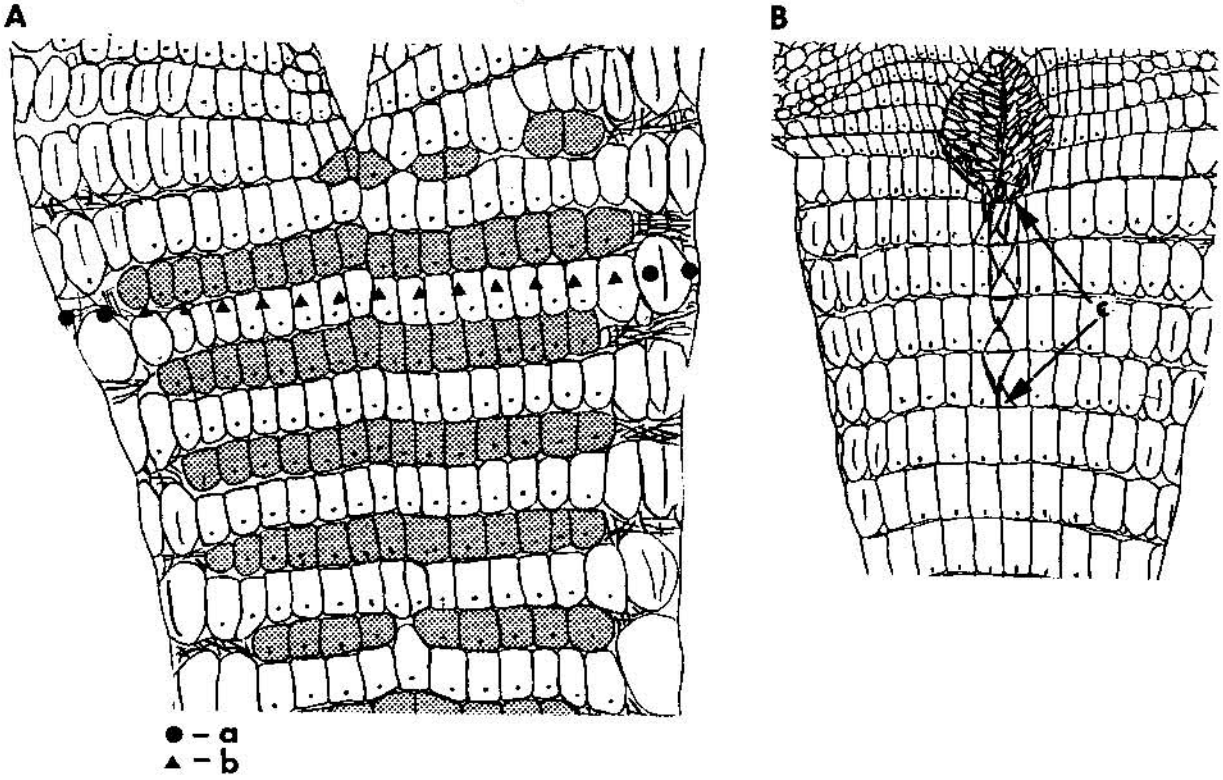


Fig. 7. Sub-caudal tail sections immediately posterior to the vent showing sub-caudal inclusions of scales. A. Dots indicate inclusions in *Zone a*, and triangles in *Zone b*. In conjunction with ISO's, inclusions in *Zone a* indicate *Crocodylus acutus*, and inclusions in *Zones a and b, Crocodylus moreletii*. B. Mid-ventral tail inclusions *(Zone c)* distinguish *Crocodylus siamensis*. (Adapted from King and Brazaitis 1971).

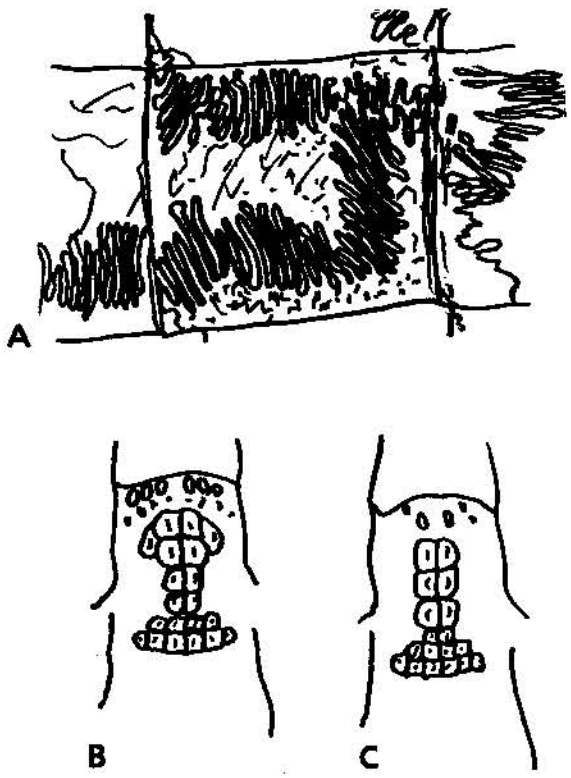


Fig. 8. A. Zig-zag worm trail, produced by a parasitic nematode, which are sometimes seen on the ventral scales of crocodilians from around the world. B. A cluster of nuchal scales followed by a series of paired scales, continuous with the dorsal scales, is typical of *Crocodylus johnstoni*. C. A series of paired nuchal scales, continuous with the dorsal scales, identifies *Tomistoma schlegelii* on hornback products from Southeast Asia.

known to occur on many species, in different parts of the world (see Foggin Chapter 36, for *Crocodylus niloticus*). They are produced by a nematode worm (genus *Paratrichosoma*) which migrates through and lays eggs in the skin (Ashford and Muller 1978).

In some products, especially those manufactured in Spain, Africa and Southeast Asia, the dorsal portions of a crocodilian's skin are incorporated into the item ("hornback" appearance). If such items have been made from the skin of *Crocodylus johnstoni* (Australian freshwater crocodile), the nuchal cluster will be nearly continuous with the dorsal scales (Fig. 8B), the flanks will be composed of rows of round uniform scales, and a round osteoderm will be present within the ventral scales (there are usually 22 to 24 transverse rows of ventral scales). Hornback products often exhibit the similar nuchal clusters of *Osteolaemus tetraspis* (African dwarf crocodile) (Fig. 6), *Crocodylus cataphractus* (West African slender-snouted crocodile) and *Tomistoma schlegelii* (Malayan false gavial) (Fig. 8C).

Skins of *Crocodylus porosus* (saltwater crocodile) can usually be identified by 30-35 transverse rows of ventral scales, which contain no osteoderms, and uniform rows of small, oval scales on the flanks. This species usually lacks enlarged post-occipital scutes behind the skull (but anterior to the nuchal cluster) which can be definitive on hornback skins. The skin of *Crocodylus porosus* produces the finest of all crocodilian leathers.

As members of the subfamily Alligatorinae lack ISO's on the body scales (Fig. 4A) (they still occur on the head), a major distinction between subfamilies can often be made easily.

Alligator mississippiensis (American alligator) skin frequently has small, round or elliptical, but poorly developed osteoderms in the scales from the pectoral and mid-ventral regions. The surface of *Alligator mississippiensis* skin assumes a smooth finish when tanned. The scar from the umbilicus

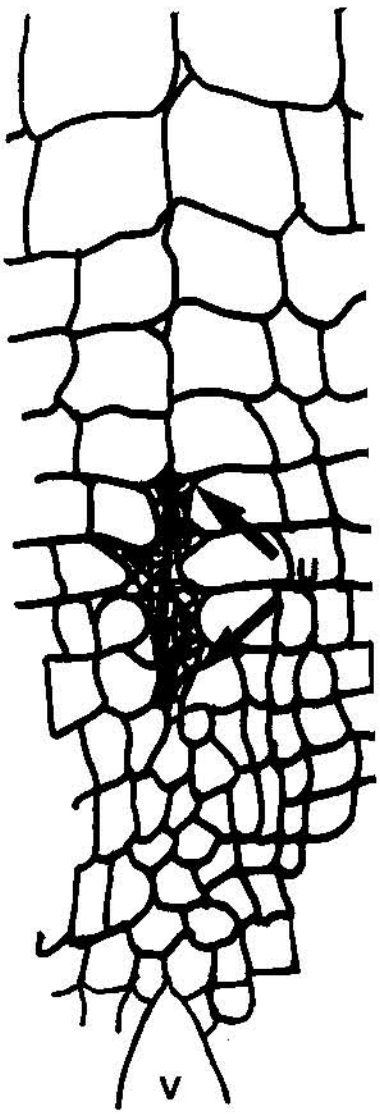
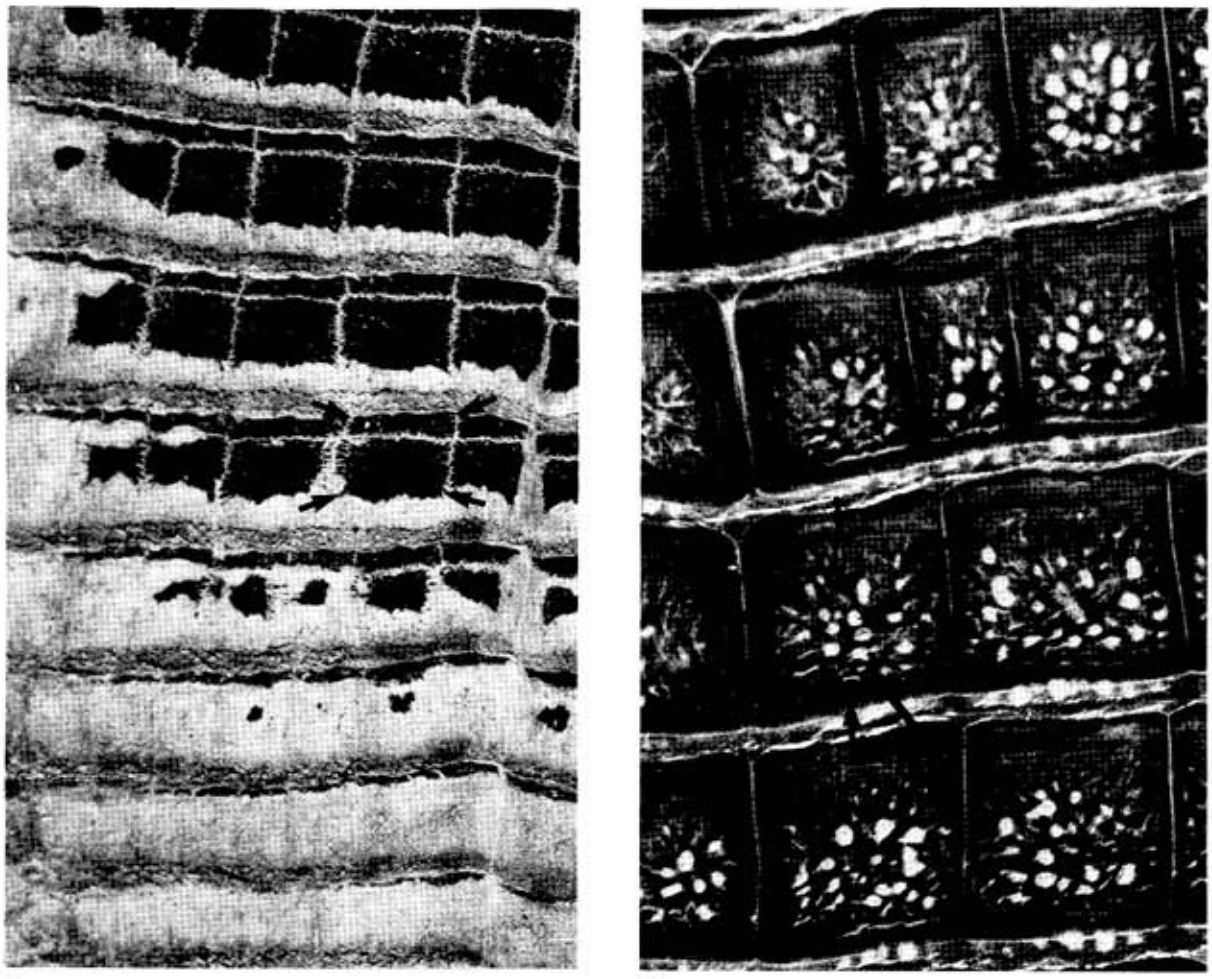


Fig. 9. Arrows indicate the fine network of creases which remains throughout life as an umbilical scar, anterior to the vent (V), in *Alligator mississippiensis*. The scar is usually seen near the top of the front panel of quality handbags made from the skin of this species. (Adapted from King and Brazaitis 1971).



A B

Fig. 10. A. Arrows indicate composite two part osteoderms in the ventral scales (typical of *Caiman* species and *Melanosuchus* niger) as viewed from the flesh side of a finished skin. B. Two part osteoderms in the ventral scales of *Caiman*; arrows indicate the surface pitting on the finished skin. (Adapted from King and Brazaitis 1971).

region in this species remains as a fine network of creases, like the strands of a spider's web, and this is often displayed at the top of fine Italian-made handbags (Fig. 9).

The skin of *Melanosuchus niger* (black caiman) differs from that of *Alligator mississippiensis*, in having a composite square osteoderm in nearly all of the ventral scales (Fig. 10A). The surface of the skin is highly polished, smooth, unpitted and relatively inflexible. Like all alligatorines, they lack ISO's. The inclusions between the ventral scale rows under the anterior tail (Fig. 7A) are definitive for *Melanosuchus niger*. In addition, the flanks are composed of 6-8 rows of large, round, poorly-keeled scales, alternating with rows of small scales. Items manufactured from the skins of *Melanosuchus niger* include handbags, coverings of desk sets, wallets, billfolds, and men's shoes.

The skin of *Caiman* species and subspecies also lack ISO's. They have large, square, composite bony osteoderms in the ventral scales (Fig. 10A), as does *Melanosuchus niger*, but when tanned, the belly scales of *Caiman* show surface pitting (Fig. 10B). *Caiman* skins may be tanned to a high gloss finish or suede-like sauvage finishes, however, osteoderms are clearly visible on the inside and outside of the skin. Bombe finishes usually produce a wrinkling effect surrounding a raised "button" on the outer surface of ventral scales.

The skin of *Caiman latirostris* (broad-snouted caiman), has highly pitted scales when tanned. The body trunk of this species is wide, and is often used to produce whole belly skins. The flank scales are composed of a single row of rectangular scales with large keels, followed by one or two alternating rows of large rectangular and small bead-like scales (Fig. 11A); there are no inclusions between the rows of tail scales.

The most commonly utilized crocodilians are the subspecies and races of *Caiman crocodilus* of South America, with the exception of *Caiman c. apaporiensis* (Rio Apaporis caiman), which may already be extinct. The skins of closely related but widely distributed subspecies and races are

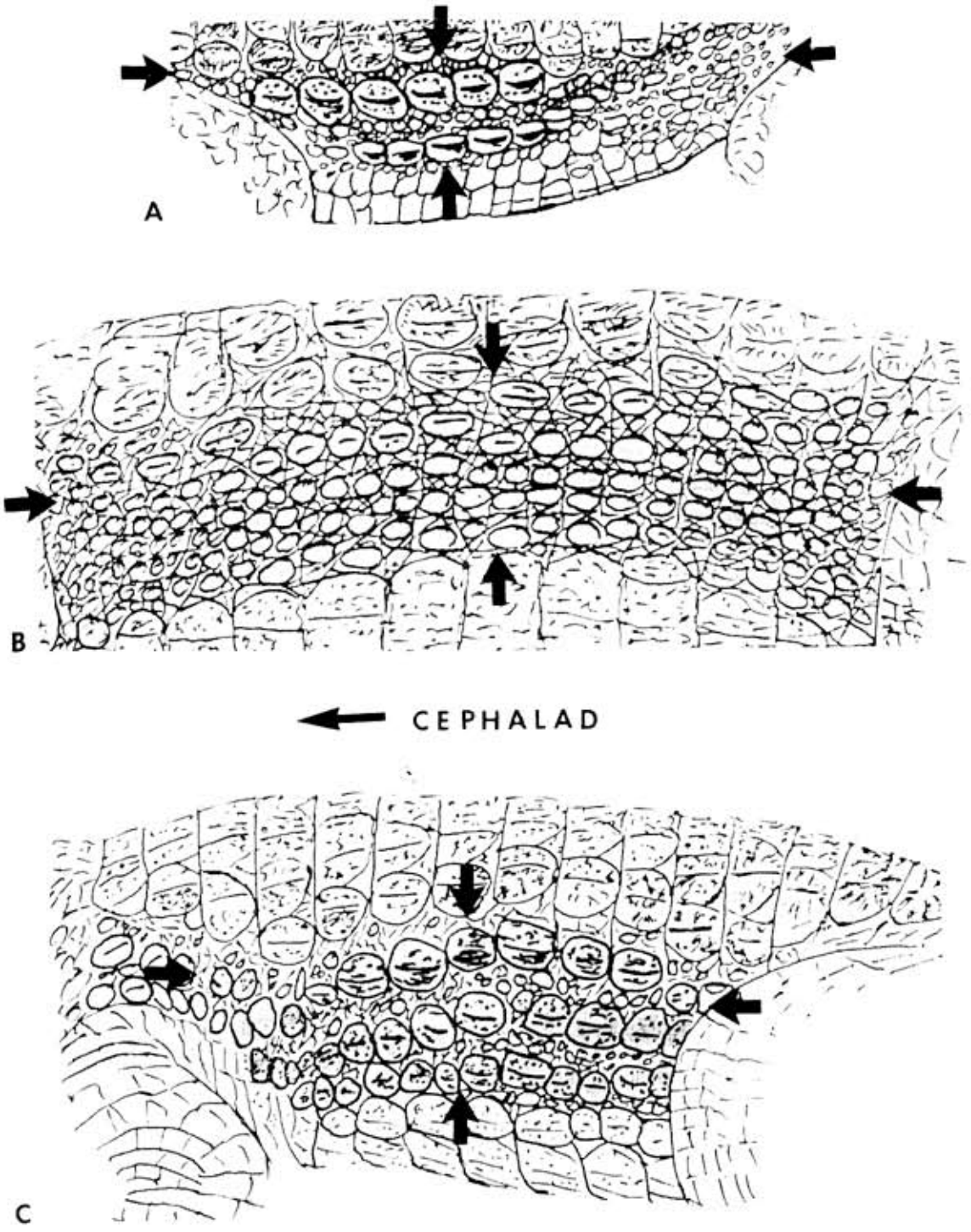


Fig. 11. Flank scalation typical of: A, *Caiman latirostris*; B, *Caiman crocodilus yacare*; and, C, *Caiman crocodilus crocodilus*.

collected throughout South America. They are mixed during tanning, usually in Bolivia and Paraguay, and are shipped as mixed consignments to consuming and manufacturing countries. Raw skins are also shipped to tanneries in Italy and France, where they are again mixed and re-exported to other countries. Most *Caiman* skins originate from Brazil, where the taking of wildlife for commercial purposes is prohibited.

While it is relatively easy to distinguish the dark raw skins of *Caiman crocodilus yacare* (the yacare caiman) from the yellow-green skins of *Caiman c. crocodilus* (the common caiman), tanned skins, whether unfinished and bleached or finished, are difficult to separate at a subspecific level. None have ISO's, all have surface-pitting (Fig. 10B), all have extensive composite, square osteoderms in the ventral scales (Fig. 10A), and none has ventral tail

inclusions (which occur in *Melanosuchus niger*). However, there are differences in the scalation of the flanks.

Melanosuchus niger has 6-8 rows of alternating small and large, round, keeled scales. The flanks of *Caiman c. yacare* are composed of 4-5 rows of round, almost unkeeled scales, separated by "chain" like interscales (Fig. 11B); the rows are more or less uniform in arrangement. The flanks of *Caiman c. crocodilus* usually have a row of enlarged, strongly-keeled scales, bounded by one or two series of oval, keeled scales, separated from each other by a space of soft skin containing small irregular scales (Fig. 11C). The flank skin of *Caiman c. fuscus* (dusty or brown caiman) is similar to that of *Caiman c. crocodilus*, except that 2-3 scale rows are arranged in straight, uniform lines and are separated from each other by a series of small bead-like scales. Small, juvenile *Caiman c. fuscus* are frequently taken from Colombia, even though a 1.2 m total length size limit exists in that country. The skins are tanned and often manufactured into men's wallets, with as many as four small belly skins being used in a single wallet.

The wide flanks of *Caiman c. yacare* (yacare caiman) are used extensively, and it is not uncommon for single shipments to contain 2000-3000 flanks. Species identification in such shipments is not difficult, but when *Caiman* skin scraps are pieced together and fastened to steer leather, usually only the deeply-pitted surface of the underlaying osteoderms in the ventral scales is available as an identifying characteristic. In such cases, the only identification possible is subfamily Alligatorinae, genus *Caiman*.

The same problem occurs when manufacturers use the cheap scraps of *Caiman* skin to make watchbands. Often such products are misleadingly labelled "crocodile", and may accordingly sell for up to U.S.$40 or more.

Key for the Identificiation of Whole Skins (Crust Tanned and Finished)

The key presented below was adapted from King and Brazaitis (1971) and Brazaitis (1973). Although it allows whole skins of most species to be identified to species, there are areas of overlap with some species groups. In all cases, identifications made using the key should be confirmed with the more detailed characteristics listed in the previous section.

1. a) Ventral scales with ISO's (Fig. 4A) 2
   b) Ventral scales lacking ISO's 10

2. a) Osteoderms (Figs 4B and 4C) present in the ventral scales, at least in the pectoral regions 3
   b) Osteoderms absent from all ventral scale regions 6

3. a) Ventral scales in 25-32 transverse rows 4
   b) Ventral scales in 22-24 rows ..... *Crocodylus johnstoni*

4. a) Flank regions (Figs 1F and 5) adjacent to the ventral belly region are composed of well developed scales, that are round or oval, but which are arranged in more or less organized rows 5
   b) Flank regions adjacent to the ventral belly region are composed of soft creased skin, containing a few well developed keeled scales which are randomly distributed (Fig. 6) ..... *Osteolaemus tetraspis*

5. a) Ventral scales in the gular, pectoral, mid-belly and sub-caudal tail regions contain large round osteoderms *Crocodylus cataphractus*
   b) Ventral scales in the pectoral and some mid-ventral scales only, with feeble, small, elliptical osteoderms ..... *Crocodylus niloticus*

6. a) Anterior sub-caudal tail regions lacking scale inclusions (Fig. 7) 8
   b) Anterior sub-caudal tail regions contain scale inclusions (Fig. 7) 7

7. a) Scale inclusions extending longitudinally from the posterior vent, medially through the first several rows of sub-caudal tail whorls (Fig. 7B) ..... *Crocodylus siamensis*
   b) Scale inclusions on the lateral portions of the anterior tail, extending transversely across onto the ventral and mid-ventral tail regions (Fig. 7A) ..... *Crocodylus moreletii*
   c) Scale inclusions restricted to the lateral portions of the anterior tail only (Fig. 7A) ..... *Crocodylus acutus*

8. a) Flank scales (Figs 1 and 5) adjacent to the belly scales are round or oval in shape 9
   b) Flank scales adjacent to the ventral belly scales are square or hexagonal in shape ..... *Gavialis gangeticus*

9. a) Ventral scales in 24 or fewer transverse rows ..... *Tomistoma schlegelii*
   b) Ventral scales in 24-26 transverse rows ..... *Crocodylus novaeguineae* or *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 ventral belly scales, or an osteoderm composed of a single bone (Figs 4B and 4C) 11
    b) Osteoderms present in belly scales are a composite bone made up of at least two sections (Figs 10A and 10B) 12

11. a) Umbilical scar present in all sized skins, appearing as a network of fine creases (Fig. 9); ventral scales in 29 or more transverse rows ..... *Alligator mississippiensis*
    b) Umbilical scar absent, and ventral scales in 28 or less transverse rows ..... *Alligator sinensis*
12. a) Ventral scales lack surface-pitting 13
    b) Surface pitting present on ventral scales . 14
13. a) Sub-caudal tail inclusions present (Fig. 7A); belly scales in 25 or more rows ..... *Melanosuchus niger*
    b) Sub-caudal tail inclusions absent, belly scales in 24 or less rows ... *Paleosuchus palpebrosus* or *P. trigonatus*
14. a) Ventral collar scales (Fig. 5) not noticeably enlarged and composed of a double row of scales; belly scales in 26-30 transverse rows ..... *Caiman latirostris*
    b) Ventral collar scales greatly enlarged, especially mid-ventrally, and composed of a single row of scales; belly scales in 20-27 transverse rows ..... *Caiman crocodilus*

DISCUSSION

Crocodilians will continue to suffer from illegal and uncontrolled exploitation as long as their skins are permitted to circulate within international trade without tags or marks that clearly identify their source of origin. Such identification needs to remain in place through the tanning process, to at least the point of product manufacture. If international and national wildlife agreements are to be effective, wildlife authorities and agencies must have the ability to trace individual skins and products in international trade, back to their primary source.

However, even with such identification, and certainly in its absence, wildlife inspectors must be trained in the identification of exotic crocodilian skins and products if they are to effectively enforce wildlife regulations. Their task would be made easier if products themselves carried at least the correct identity of the species from which they are made. This would also assist consumers, who by and large have little understanding of the differences between crocodilians used in trade, nor the plight of some species as a direct result of that trade.

To date, we have only scratched the surface in the forensic identification of wildlife products. New and better tools and techniques are needed to cope with the regulation problems created by new markets in meat, teeth for jewellery and trinkets, or even bones for fertilizer. The problems are by no means unique to crocodilians. Proposals for the exploitation of sea turtles are being considered, yet the skins of one species can rarely be distinguished from those of another. How can trade be controlled within the guidelines required by international agreements?

The widespread use of biochemical techniques to identify wildlife products is millions of dollars and research years away from practicality. However, investigations into the molecular identification of crocodilians have been carried out on blood (Densmore 1983) and meat and blood (Joanen, pers. comm.), and additional research is underway under the joint auspices of the New York Zoological Society, the Long Island University and the World Wildlife fund (USA).

Better and more comprehensive systems for marking wildlife products and monitoring their movements in commercial trade can be developed, just as can improved methods of forensic identification. In the interim, significant advances can be made if the techniques that are currently available are used more frequently. In this regard, it is hoped that the information contained in this chapter is of use to others faced with the problems of forensic identification of crocodilian skins and products.

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