New Faces, New Names and Old Friends: an Overview of the *Kinosternon* Diversity Project and Illustrated Guide to Morphological Characters (Testudines: Kinosternidae).

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ABSTRACT. – The mud turtle genus *Kinosternon* of the Testudines family Kinosternidae represents the most speciose and most widely distributed grouping of extant freshwater turtles. Currently 33 taxa are recognized, with an aggregated geographical range from New England west and south throughout the United States, Mexico, Central America and South America to northern Argentina (TTWG 2021). Belying the species' biodiversity is a taxonomic quagmire of lost and destroyed holotypes, unrecorded locality data, misidentification of specimens and characters, underevaluated morphology, lack of skeletal material, incomplete understanding of distributions and an avalanche of synonyms and literature. We undertook a taxonomic and morphological revision of specimens and species groups from southern Texas south throughout Mexico, Central and South America, resulting in numerous new proposals and discoveries that clarify distribution, morphology, taxonomy and nomenclature. We anticipate the formal results to be presented over a landscape of more than 40 contributions. In the first contribution, we present an overview of the morphology of the genus, and the methodology, the challenges faced and a visual guide to the suite of 246 morphological character states that we utilized to conduct the research.

Keywords: Testudines; Kinosternidae; *Kinosternon*; biodiversity; character guide; genus revision.

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Figure 1. The colorful countenance of a male *Kinosternon acutum* peeks out.

INTRODUCTION

The Testudines family Kinosternidae accommodates four extant genera which are confined to the Americas. While the fossil record preserves numerous diverse but now extinct genera, three of the living ones, *Claudius, Staurotypus* and *Sternotherus*, harbor a relatively small number of species (one, two and five respectively). The fourth, *Kinosternon*, represents the most speciose and most widely distributed grouping of extant freshwater turtles today. Currently 33 taxa are recognized, with an aggregated range from southern New England west and south throughout the United States, Mexico, Central America and South America into northern Argentina (TTWG 2021). Many near offshore islands harbor populations that are natural while others are potentially introduced. In addition to the unique morphological characters that strictly separate *Kinosternon* from all other turtles, the biodiversity of the genus has steadily been recognized, and notably been punctuated by the renewed re-recognition of former and newly discovered micro-endemic species and subspecies (Iverson, 1981; López-Luna *et al.*, 2018; Loc-Barragán *et al.,* 2020).

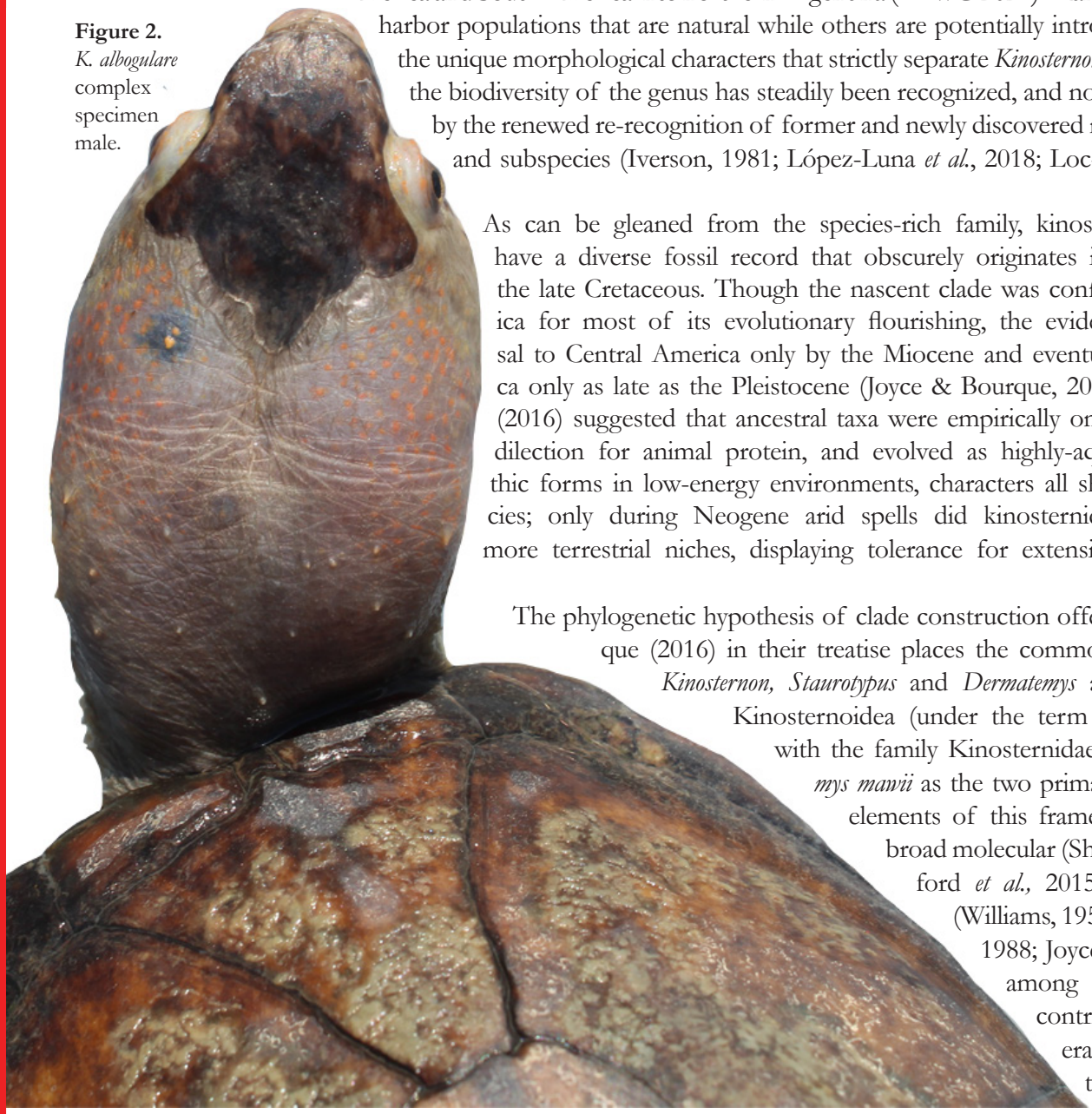

Figure 2. *K. albogulare* complex specimen male.

As can be gleaned from the species-rich family, kinosternids and their kin have a diverse fossil record that obscurely originates in the Campanian of the late Cretaceous. Though the nascent clade was confined to North America for most of its evolutionary flourishing, the evidence indicates dispersal to Central America only by the Miocene and eventually to South America only as late as the Pleistocene (Joyce & Bourque, 2016). Joyce & Bourque (2016) suggested that ancestral taxa were empirically omnivorous with a predilection for animal protein, and evolved as highly-aquatic freshwater-benthic forms in low-energy environments, characters all shown in modern species; only during Neogene arid spells did kinosternids exploit additional, more terrestrial niches, displaying tolerance for extensive land colonization.

The phylogenetic hypothesis of clade construction offered by Joyce & Bourque (2016) in their treatise places the common ancestor of extant *Kinosternon, Staurotypus* and *Dermatemys* as the total clade of Kinosternoidea (under the term Pan-Kinosternoidea), with the family Kinosternidae and species *Dermatemys mawii* as the two primary crown clades. The elements of this framework were based on broad molecular (Shaffer *et al.,* 1997; Crawford *et al.,* 2015) and morphological (Williams, 1950; Gaffney & Meylan, 1988; Joyce *et al.,* 2004) support, among many other authors' contributions and we operate in agreement with these arrangements.

Berry (1978) diagnosed the genus *Kinosternon* as distinguishable from all other extant kinosternid genera by the following combination of five characters (our comments in square brackets [ ]):

1) Plastron with two transverse, free kinetic hinges [with the exception of *K. herrerai* in which the posterior lobe is fixed (akinetic)] bordering anterior and posterior margins of the abdominal scutes (anterior edge of hyoplastral bone, and posterior edge of hypoplastral bone) [the abdominal scutes are absent in *Kinosternon*, see below for current nomenclature and the debate surrounding it].

2) Gular scute well developed, never shortest plastral scute at midline [with the exception of some large male adult *K. hirtipes* complex specimens in which the midline gular scute length is equal to the inter-antero-humeral scute sulcus].

3) Tails of males and females with terminal horny spines, larger in males than in females (except in *K. angustipons* in which tails in both sexes lack spines).

4) Entoplastral bone absent [also see Hutchison & Bramble (1981) for remarks on evolutionary development].

5) Five to six neural bones present [four neurals present in some *K. integrum* shells; also the final neural in some specimens of *K. integrum* are minuscule, giving appearance of only four neurals].

While almost all other families of both fossil and extant turtles have agreed upon consensus of the nomenclature of the carapace and plastron in skeleton and scutation, mud turtles continue to lack clarity in the nomenclature of plastral scutes, with multiple contributors over the last century applying different usage of the commonly known gular, pectoral, humeral and abdominal scutes (Hay, 1908; Iverson, 1981, Hutchison & Bramble, 1981; Legler & Vogt, 2013).

Figure 3. *K. albogulare* complex specimen female.

Figure 4. Up close of the bridge with axillary and inguinal scutes in this *K. albogulare* complex specimen.

The discontinuity stems from the ontogeny of fossil and extant species, as comprehensively explored by Hutchison & Bramble (1981), who proposed a comparative homology which concluded that modern kinosternids evolved differential anterior plastron scutes (gulars, intergulars) and entirely lacked both traditional pectoral and abdominal scutes. Those authors found that ancestral lineages exhibited sagittally paired gular, humeral, abdominal, femoral and anal scutes, but extragulars (gular scutes lateral to a medial gular or intergular scute) and pectoral scutes were symplesiomorphically absent. The abdominal scutes apparently became vestigial and were entirely lost. The anteromedial scute labeled today as an intergular scute became a novelty, displacing the paired gular scutes parasagittally (parallel to the sagittal plane). In subsequent lineages, in direct response to the creation of a fully kinetic anterior plastral lobe, the humeral scute was perpendicularly severed to the midline along the newly developed epidermic and cartilaginous hinge between the epiplastron bone and the posterior hyoplastron bone, the entoplastron bone being completely lost. The partitioned humeral scale has been labeled (Hutchison & Bramble, 1981; Joyce & Bourque, 2016) as humeral I (for the anterior component that covers the posterior portion of the anterior lobe i.e. posterior epiplastra) and humeral II (for the posterior component that covers the anterior portion of the hyo-hypoplastral (fixed) bone). Legler & Vogt (2013) in their treatise of the freshwater turtles of Mexico abandoned the plastral scute terminology for mud turtles and used a simple anterior to posterior numbering system. We offer here a proposed nomenclature of the mud turtle plastral scutation and sulci, illustrated and labeled in a diagram below, which is congruent with both historical and modern knowledge and discovery, and hence which can serve as a unified terminology.

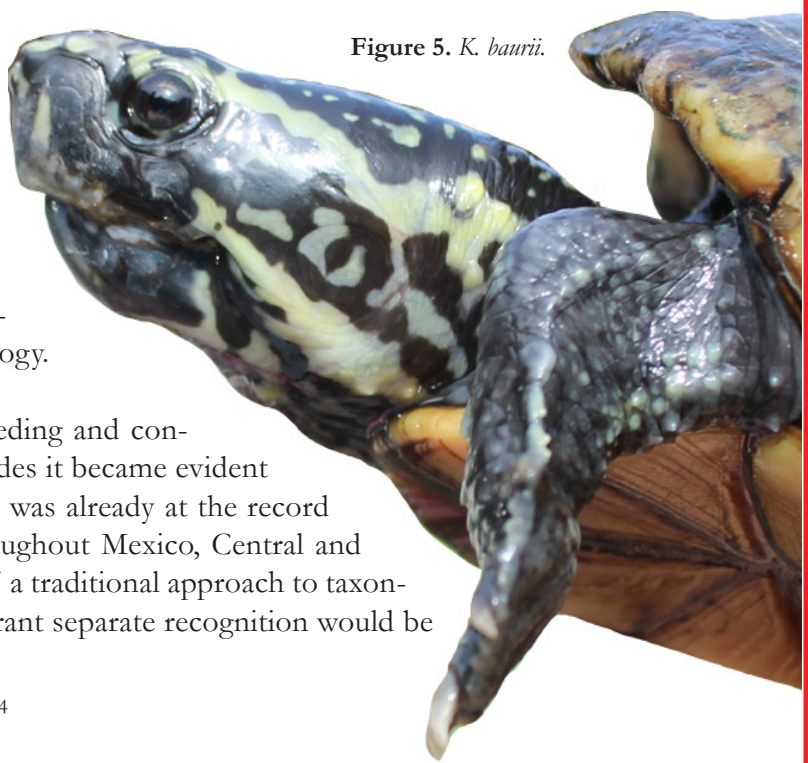

Figure 5. *K. baurii.*

During the course of these authors' captive breeding and conservation efforts with mud turtles over the last few decades it became evident that while the consensus species' diversity of the group was already at the record high, it still remained significantly under-evaluated throughout Mexico, Central and South America. Initially we entertained the possibility of a traditional approach to taxonomy whereby a population of turtles considered to warrant separate recognition would be

described and morphologically compared to its nearest congeners. However, we learned to appreciate the complexities that motivated the extensive efforts of Iverson, Berry and Legler to tackle the extensive disorder within the nomenclatural, morphological and phylogenetic history of the genus.

Particularly formidable is the lengthy flurry of concatenated synonyms that cloud strict species recognition, with the holotypes of many prominent early taxa having been lost, discarded or destroyed over the centuries. The holotypes of two of the most common and widely spread species, *Kinosternon scorpioides* of Central and South America, and *Kinosternon integrum* of Mexico, have been untraceable and hence unseen for more than a hundred years. The early scientific descriptions of many species are rudimentary in nature, failing both to identify and distinguish the intended species from others under the modern framework of taxonomy and knowledge.

Figure 6. Strongly sculptured venter of a *K. leucostomum.*

Further complicating the matter are the pitfalls of the complete absence of some key specimen locality data, confronting chelonologists with the task of having to trace the travels and field histories of the original collectors. As a result, modern methods to taxonomically evaluate the diverse populations within the ranges of these taxa have been frequently impeded.

With the advent of numerous and comprehensive studies now formally published on the genetics of mud turtle populations, we opted for a comprehensive taxonomic renovation. Accordingly we directly photographed and examined or obtained images from our institutional colleagues of existing holotypes, paratypes and syntypes of the *Kinosternon integrum, K. hirtipes, K. scorpioides* and newly recognized *K. albogulare* species groups throughout the ranges, as well as those of comparative species not requiring revision from other *Kinosternon* groups. We examined, photographed and meristically studied more than fifteen hundred museum-held, privately-held and living specimens of all ontogenetic stages from hatchlings to old adults, as well as been provided data and images of hundreds of other specimens from prior researchers used in already published studies.

Over the course of more than 40 new original contributions we propose and empirically support significant changes to the formal taxonomic recognition of taxa both morphologically and zoogeographically. We formally designate neotypes and lectotypes from existing syntypes or from the pool of conspecific long-held museum accessioned specimens, proceeding to strictly define nomenclature, morphology and distributions. While some new taxa are designated as new micro-endemics, other new taxa are surprisingly common and widely distributed, having been concealed under previously broad former umbrella names.

METHODOLOGY & NOTES ON CHARACTER STATES

Kinosternon specimens of all life stages housed in the Yale Peabody Museum (YPM), American Museum of Natural History (AMNH) and Museum of Comparative Zoology, Harvard (MCZ) were personally examined and photographed by the senior author and notes on their morphology, condition, identification and coloration were recorded, as were those aspects of live specimens in the collections of the additional authors and our herpetological colleagues. Photographs provided by additional colleagues as well as photographs of specimens in zoological and museum institutions were also utilized (see 'museum acronyms' subsequent to the Acknowledgements section). Images as well as field data were generously shared by further colleagues throughout the world. The total base of live and preserved specimens examined numbered approximately 1500. Accounting of specimens and specimen registration numbers will be included in the summary of each species group.

All pertinent herpetological published literature as well as unpublished data concerning *Kinosternon* distribution, morphology, taxonomy, paleontology, nomenclature and ecology were personally consulted by the authors. Field guides and herpetological compendia were also researched.

The nomenclature of the shell, skeleton, scutes and scales utilized in this project are aggregated in this current guide to character states and follows the works of Iverson, Berry, Legler, Hutchison & Bramble, Bourque and Joyce & Bourque (see Literature Cited below for these specific resources) as well as that of Zangerl (1969).

Thus, 'pleural' refers to the lateral outer keratinous scutes covering the costal bones, 'nuchal' is reserved for the specific bone, and the anterior median scute of the carapace margin is referred to as the cervical scute. Marginals refer to the keratinous scutes covering the peripheral bones.

Marginal scutes number 11 on each side of the carapace, and we use the shorthand designation of M# (i.e., anteriormost marginal is M1, the next M2 etc.); likewise pleural scutes number 4 on each side of the carapace and we use P# for shorthand reference; and vertebral scutes number 5 medially on the carapace, and we use V#, numbering from anterior to posterior.

For the plastral scutes, the following shorthand notations are used: IG= intergular scute; IGS= Intergular sulcus; IGSL= intergular scute straight length; IAnH = interanterohumeral sulcus; IPH= interposterohumeral sulcus; IF= interfemoral sulcus; IAn= interanal sulcus. The gular scutes are denoted as G. The reduced scutes at the anterior bridge-peripheral suture are called axillary scutes and posterior ones called inguinal scutes. See section below entitled "Nomenclature of the *Kinosternon* Shell" for labeled illustration of these scutes and sulci.

Lastly, we use the shorthand symbol of 'x' as a replacement for the word 'times' when conveying multiplication factors in the metric characters to avoid repetitive cluttering in the voluminous comparative data. For example, Carapace Length versus Carapace Width which may be '2 times' is written as '2x' .

A scaffold of 246 *numerical* individual character states were compiled and evaluated, and then structured among 140 *enumerated* characters, all of which are described in detail and illustrated in this current contribution. The vast majority of these have not been applied to or included in prior publications that described or compared novel and existing taxa. The 246 character states were applied to adult *Kinosternon* specimens of both sexes in order to record the most typical morphological states that could potentially be used to identify and define sensu stricto species and subspecies concepts.

We subdivided the 140 *enumerated* character states into three categories for application as follows:

The morphology and metrics of the carapace section covers Characters 1 through 51 and examines the morphology, metrics and nomenclature of the carapace including shapes, scutes, and sulci.

The morphology and metrics of the plastron; advanced metrics of the shell section covers Characters 52 through 104 and examines the morphology, metrics and nomenclature of the plastron including shapes, scutes, and sulci, as well as metrics which include carapace and inframarginal scutation data.

The morphology and metrics of the head and limbs; coloration and patterns of the species section covers Characters 105 through 140 and examines the morphology, metrics and nomenclature of the head, limbs, tail and scales as well as overall coloration and patterns of the species.

Not all of these characters are elaborative; as such several of them became useful only for testing their utility as criteria and/ or establishing their congeneric variability and well as establishing a suite of character states that are shared by species groups or species in the genus.

Joyce & Bourque (2016) extensively treat the skeletal morphology of fossil and extant kinosternids including the cranium, shell and postcranium anatomy. Additional contributions to these select areas of study are in preparation but due to the overall paucity of skeletal material from numerous specific taxa for direct comparative research, skeletal considerations do not prominently factor into our evaluation of the current diversity.

Figure 7. Ventral view of the tail with terminal keratinous spur in this adult male *K. integrum* complex specimen. This spur earned the moniker for the 'scorpion mud turtle' but it is present in both sexes of all known *Kinosternon* species with the exception of *K. angustipons* in which it is absent entirely.

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Museum acronyms: AMNH (American Museum of Natural History); ANSP (Academy of Natural Sciences, Philadelphia; CAS (California Academy of Sciences); MCZ (Museum of Comparative Zoology); MNHN (Muséum National d'Histoire Naturelle); USNM (Smithonian National Museum of Natural History); UAZ (University of Arizona); UF (University of Florida, Florida Natural History Museum); UMMZ (University of Michigan, Museum of Zoology; YPM (Yale Peabody Museum).

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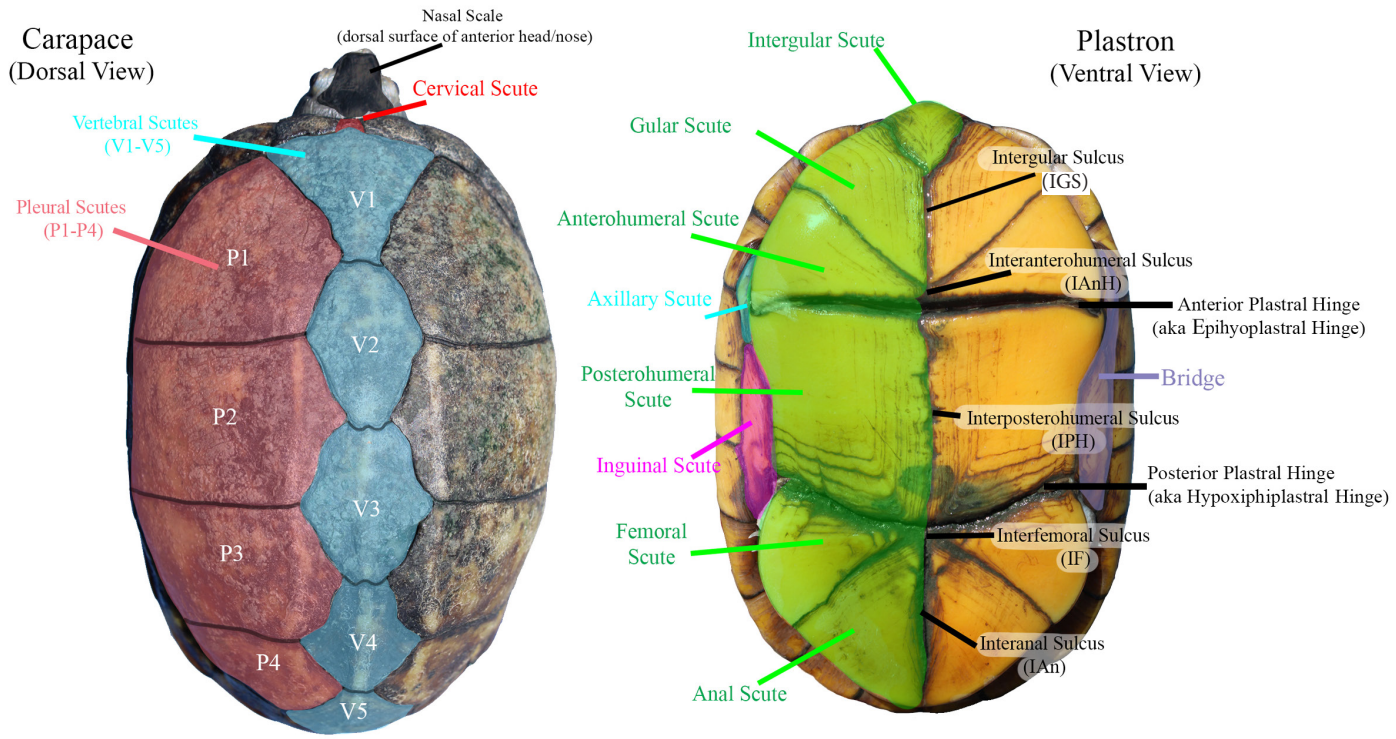
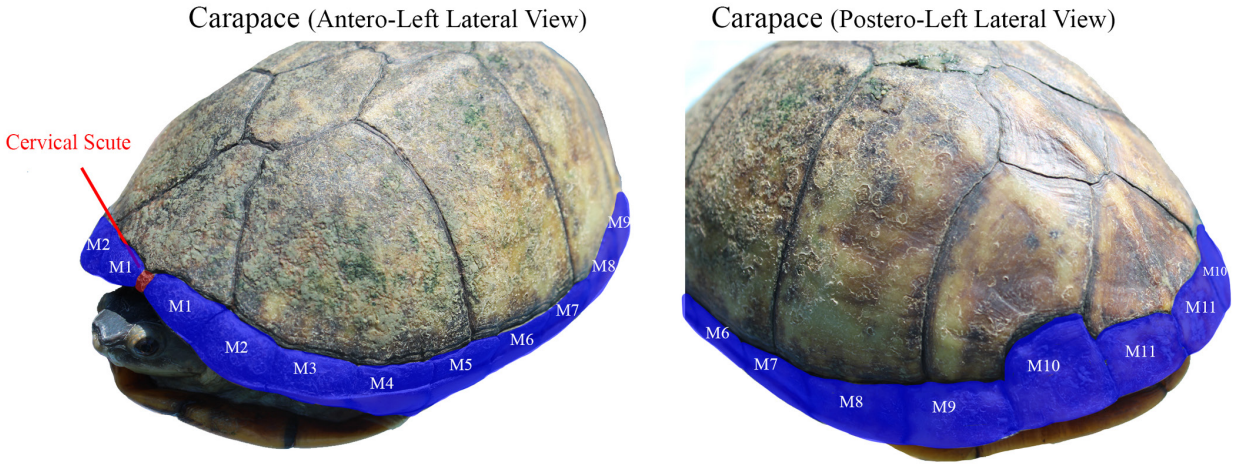
Figure 8. Up-close of the beautifully-patterned head of a *K. scorpioides* complex specimen.

Nomenclature of the *Kinosternon* Shell





Marginal Scutes
(M1 - M11)

Characters 1 through 51

Morphology and metrics of the carapace.

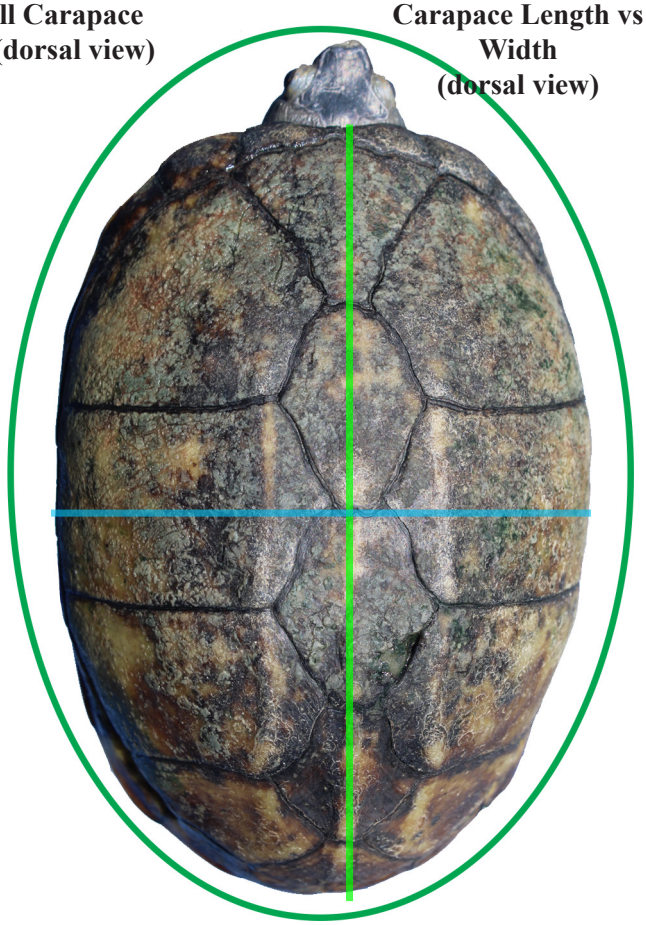
Figure 9. Male (left) and female *Kinosternon alamosae*.

Character 1: Overall Carapace Shape

This character (dark green oval) is determined from dorsal view. Common states include oval, elongated oval, pear or circular (adult female specimens may often be rounder or more circular than males). For examples of the variation across species, the demonstrated shape is that of a female member of the *K. albogulare* complex (right), as oval, but below are dorsal views of male *Kinosternon scorpioides seriei*, (elongated oval, below left) and *K. flavescens* (circular, below right).

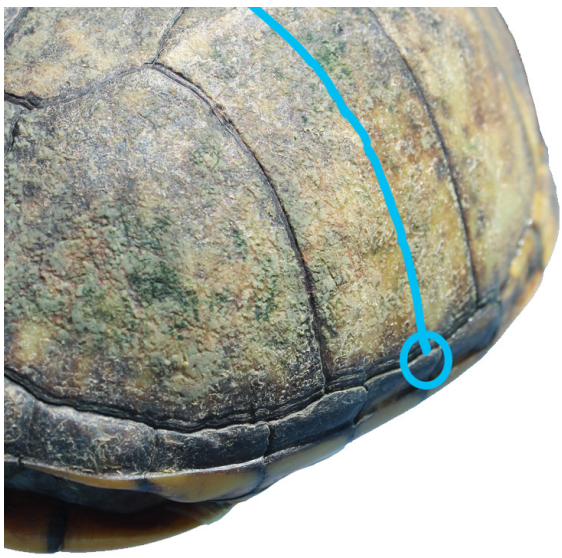
Character 1: Overall Carapace Shape (dorsal view)

Characters 2a and 2b: Carapace Length vs Width (dorsal view)



Characters 2a and 2b: Carapace Length vs Width

This character is determined from dorsal view and represented by a factor (Character 2a) – maximum midline length (light green, above right, recorded as straight carapace anteriorly to posteriorly down the midline) divided by maximum width (light blue, above right, recorded as straight perpendicular to the midline at the level of maximum width). For elongated specimens and species, the factor will be a higher number, and lower and possibly subequal in more circular ones. For example the demonstrated specimen in the *K. albogulare* complex has a factor of 1.45x, but in the specimen of *Kinosternon scorpioides seriei* (above left) the factor is 1.7x and 1.3x in the specimen of *K. flavescens* (above center).



Character 2b is simply the notation of where the maximum width occurs in terms of the marginals (in the case, at the posterior M6 position, blue circle, right).

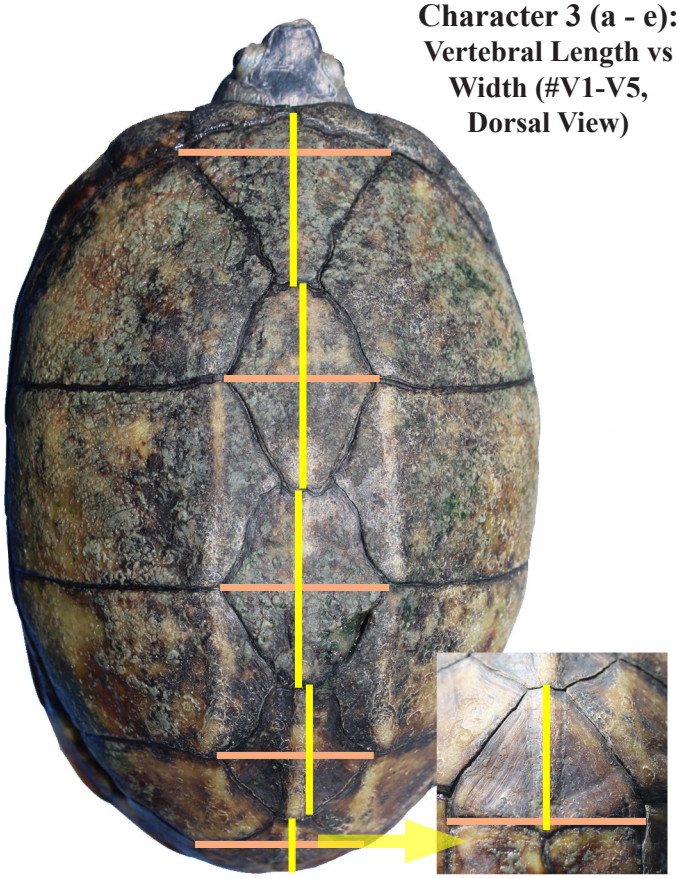
Characters 3a-3e: Vertebral Length vs Vertebral Width

These characters compare the length of each vertebral scute (yellow line) against the width of each vertebral scute (peach line) as a factor (length divided by width). The length is measured straight down the midline of each scute, for example in V1, from the shared posterior sulcus of the cervical scute to the V1-V2 sulcus. The width is calculated perpendicular to the midline at maximum width. In V1 this would occur at the conjunction of the marginal sulcus and V1-P1 sulcus; for V2 at the V2-P1-P2 conjunction (then respectively for V3 and V4).

For V5 (shown in lower caption, in direct on posterior view for ease of reference) this would occur at the conjunction of the V5-M10-M11 intersection. For most taxa the length of V1 through V4 will be longer that the width, hence the ratio would be numerically above 1. For V5, typically lower than 1. The higher the factor the more antero-posteriorly elongated the scute shape overall.

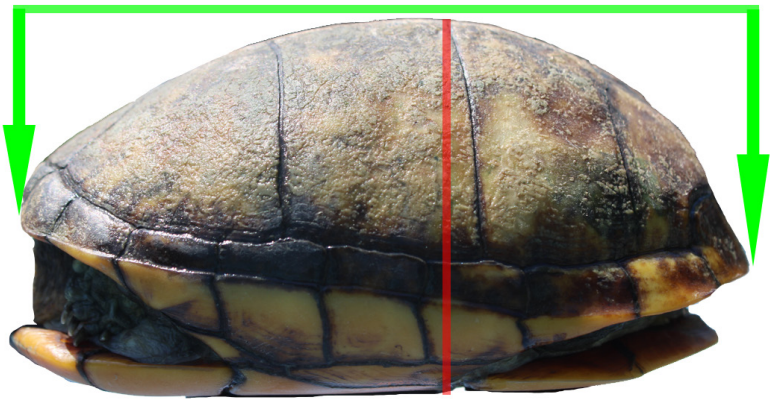
Vertebrals are mostly longer than wide in this member of the *K. albogulare* complex (right), but wider than long in a female *Kinosternon integrum* (below left) and *K. herrerai* (below right).

Character 3 (a - e): Vertebral Length vs Width (#V1-V5, Dorsal View)



5th Vertebral scute (V5), direct on view

Characters 4a and 4b:
Carapace Length vs Shell Depth (lateral view)



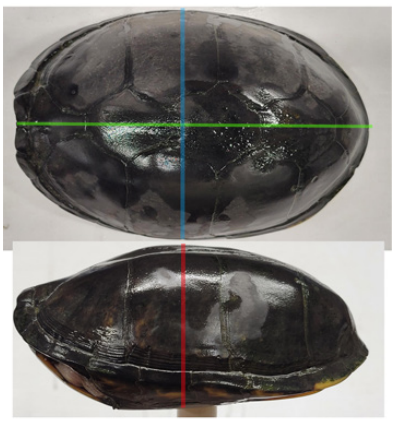
Characters 4a and 4b: Carapace Length vs Shell Depth

This character (shown in a direct left lateral view) provides the factor (Character 4a) of the carapace length (light green line, as in Character 2, calculated straight down midline of carapace) versus shell depth (also known as shell height, in red line). The shell depth is calculated at maximum occurrence perpendicular to the lateral length of the shell. The point of maximum depth is denoted (Character 4b) in reference to the vertebrals. In this example, Character 4a (factor of length divided by width) is almost exactly 2.0x and occurs at the V3-P2-P3 sulcus conjunction (Character 4b, red circle). Specimens and species with longer carapaces or higher length-to-depth ratios will have relatively shallower shells. For species such as *Kinosternon scorpioides seriei* (below left) the factor is 2.60x and it is 1.85x in this *K. cruentatum* (below right).

Character 4c:
Carapace Width vs Shell Depth

Character 4c: Carapace Width vs Shell Depth

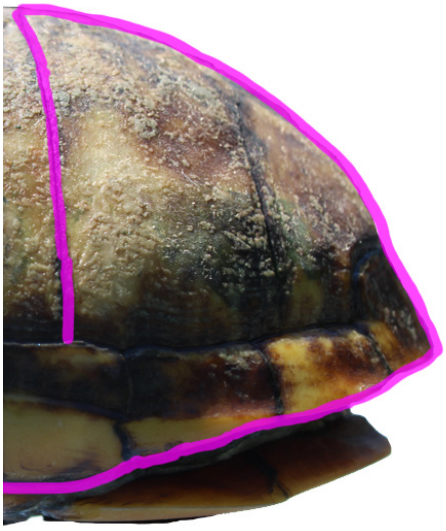
This character (right) provides the factor (Character 4c) of the carapace maximum width (light blue, recorded as perpendicular to the midline at the level of maximum width) versus shell depth (also known as shell height, in red line). Here it is 1.41x in this *K. integrum* complex specimen.

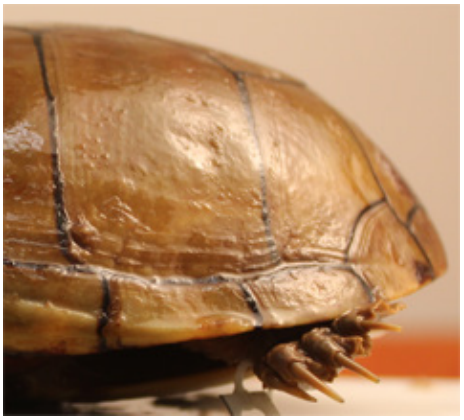


Character 5a: Profile Posterior Shell

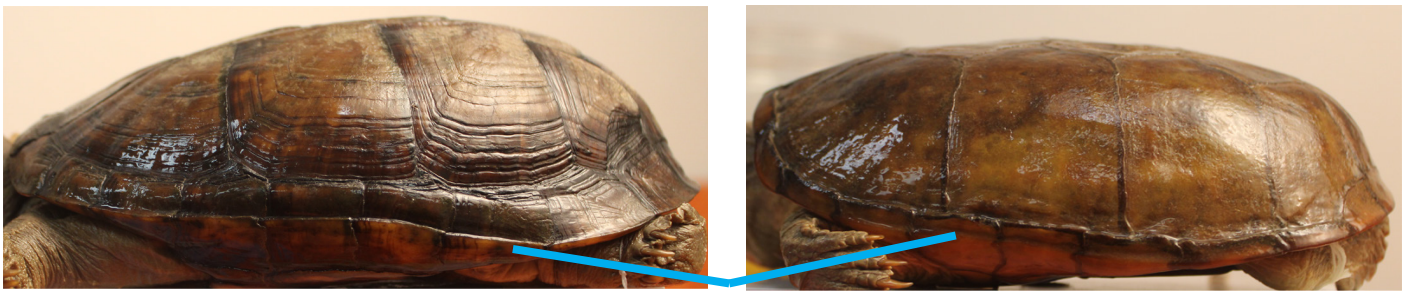
This character of the shell profile is viewed directly laterally, and describes the contours of the hind shell posteriorly from the P2-P3 sulcus as well as the proportions and arrangement of the P3, P4 and M8-M10 scutes. Through difficult to quantify, this profile is a valuable aspect that carries species-specific diagnoses. The model illustrates a female specimen of a species in the *K. albogulare* complex; below, clockwise from upper left the additonal taxa are: *K. hirtipes tarascense; K. alamosae; K. abaxillare; K. dunni, K. leucostomum, K. scorpioides seriei.*

Character 5a:
Profile Posterior Shell
(lateral view)





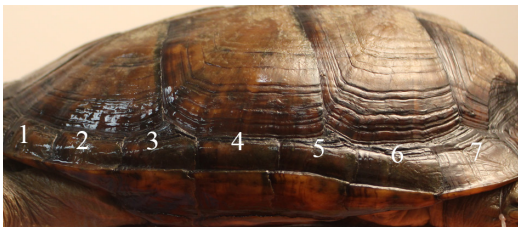
Character 5b:
Lateral Marginal Curling
(lateral view)



Character 5b: Lateral Marginal Curling

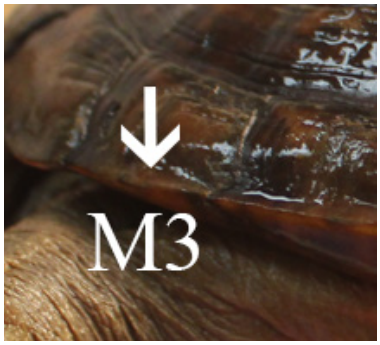
This character of the lateral shell profile is viewed directly laterally, and describes the relative degree of dorsal curling of the lateral marginals (blue line). In this *K. scorpioides seriei* the curling is advanced (above left), but moderate to minor in this *K. herrerai* (above right).

Character 5c:
Marginal Curling Count



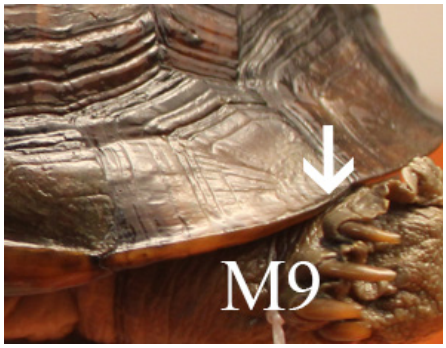
Character 5c:
Marginal Curling Count
This character records the number of marginals involved in the dorsal curling of the lateral carapace. Here it is 7 marginals in all.

Character 5d:
Initial Marginal Curling



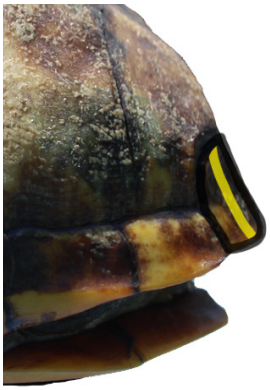
Character 5d:
Initial Marginal Curling
This character records position and marginal number where the dorsal curling initiates. Here it is mid-point M3.

Character 5e:
Final Marginal Curling



Character 5e:
Final Marginal Curling
This character records position and marginal number where the dorsal curling initiates. Here it is posterior M9.

Character 6:
M10 Flaring
(lateral view)



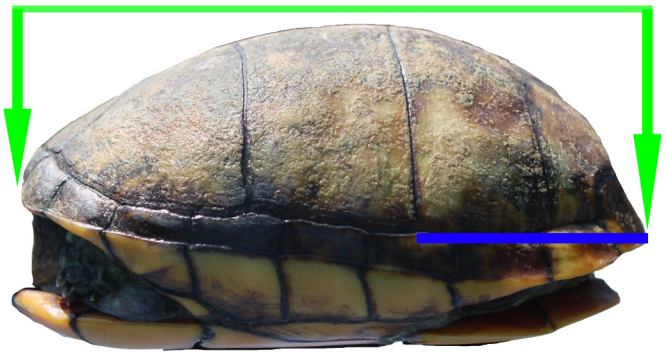
Character 6: M10 Flaring

The 10th Marginal in *Kinosternon* plays a large role in the diagnosis of species and species groups (see also Characters 33; 35-41). In the model at left, a female specimen in the *K. albogulare* complex, M10 shows a moderate diagonal flaring outward. In *K. alamosae* the flaring is entirely absent as M10 is structured vertically (right above) and in *K. abaxillare* the flaring shows stronger horizontal flaring (below right)

Character 7: Carapace Length vs Posterior Length

This character records the factor of the carapace length (green line, measured as straight carapace anteriorly to posteriorly down the midline – green arrow to green arrow) over the length of the posterior portion of the carapace (blue line, measured straight posterior from the junction of the P2/P3/M7 sulci to the level of the posteriormost point of the shell (posterior green arrow, M11). In the *K. albogulare* complex specimen the factor is 2.70x, exactly as it is in this K. acutum (below left) but is 2.40x in this *K. scorpioides seriei*, below right).

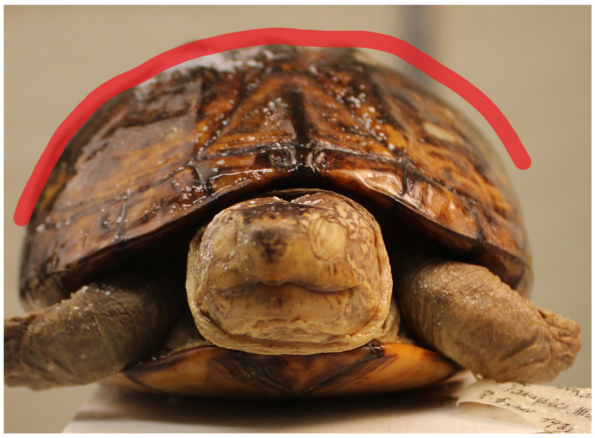
Character 7:
Carapace Length vs Posterior Length



Character 8: Anterior Arch of Carapace

Seen in a directly anterior view, the overall arch of the anterior carapace (red line) helps to indicate the overall shell depth and anterior slope. In this *Kinosternon cruentatum*, the arch is relatively even but low, but is steep in this *K. albogulare* complex (below left) but even lower to depressed in this *K. abaxillare* (below right).

Character 8:
Anterior Arch of Carapace (anterior view)

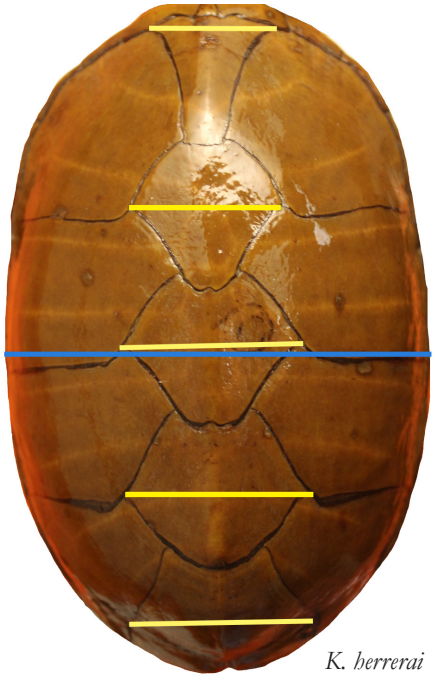


Character 9: Posterior Arch of Carapace

Seen in a directly posterior view, the overall arch of the posterior carapace (orange line) helps to indicate the overall shell depth and posterior slope. In this *Kinosternon cruentatum*, the arch is relatively even and moderately high, forming a brief, ridged plateau at the apex. It is steep in this *K. albogulare* complex specimen (below left) but even lower to depressed in this *K. abaxillare* (below right).

Character 9:
Posterior Arch of Carapace (posterior view)

Characters 10a - 10e:
Vertebral Widths vs Carapace Width



K. herrerai

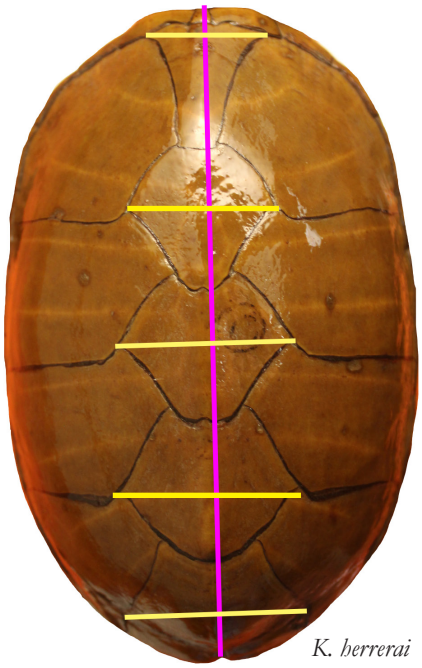
Characters 10a - 10e:
Vertebral Widths vs Carapace Width

This character describes the ratio factor of the carapace width (blue line) to that of each of the widths of V1 through V5 (respective yellow lines). Carapace width is measured as straight perpendicular to the midline at the level of maximum width (see Characters 2a/2b). Vertebral scute width is measured straight at point of greatest width.

Characters 11a - 11e:
Vertebral Widths vs Carapace Length

This character describes the ratio of the carapace length (magenta line) to that of each of the widths of V1 through V5 (respective yellow lines). Carapace length is recorded as straight carapace anteriorly to posteriorly down the midline (see Characters 2a/2b).

Characters 11a - 11e:
Vertebral Widths vs Carapace Length



K. herrerai

Characters 12a - 12e:
Vertebral Lengths vs Carapace Length

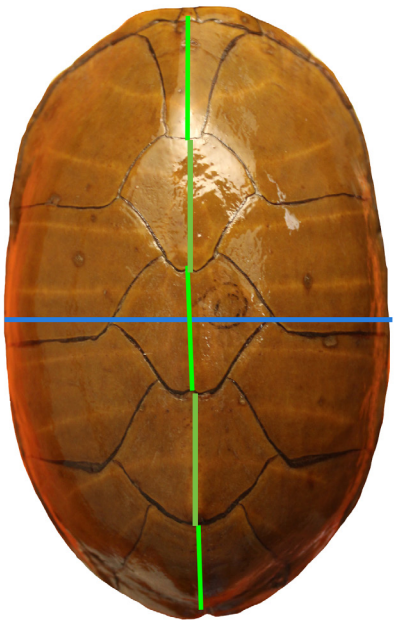
Characters 12a - 12e: Vertebral Lengths vs Carapace Length

This character describes the ratio of the carapace width (blue line) to that of each of the widths of V1 through V5 (respective green lines). Carapace width is measured as straight perpendicular to the midline at the level of maximum width (see Characters 2a/2b). Vertebral length is measured straight down the midline between the sulci.

Characters 13a - 13e: Vertebral Lengths vs Carapace Width

This character describes the ratio of the carapace length (magenta line) to that of each of the widths of V1 through V5 (respective green lines). Carapace length is recorded as straight carapace anteriorly to posteriorly down the midline (see Characters 2a/2b). Vertebral length is measured straight down the midline between the sulci.

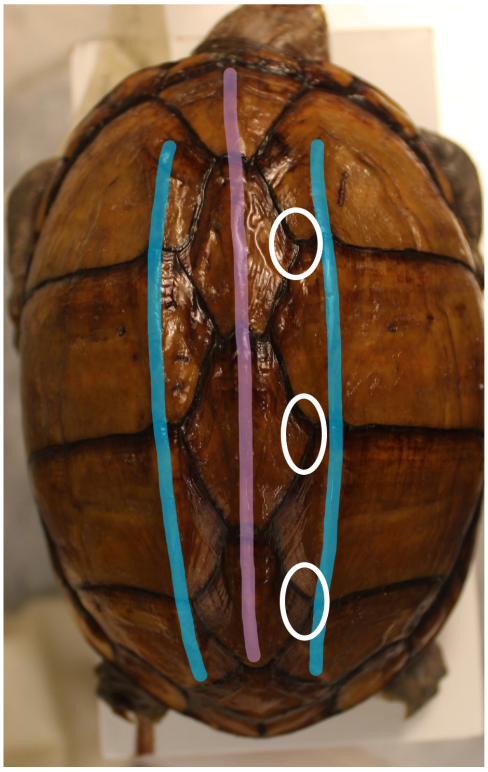
Characters 13a - 13e:
Vertebral Lengths vs Carapace Width



Character 14: Carapace Carination

In *Kinosternon*, carination (also known as keeling) plays an important diagnostic. The carination is a longitudinal ridge in the underlying carapace bones, often stretching from the anterior scutes to the posterior ones. In some species only a central midline carination is present (termed unicarinate - right, outlined in lavender in the model); in others sagittal lateral keels are present (outlined in blue), creating a 3-keeled carapace termed tricarinate, the blue plus lavender lines) such as this *K. cruentatum* in the model at right; in others, no trace of carination is present as in the *K. herrerai* (termed acarinate, shown in Character 12 model above).

Character 14:
Carapace Carination



Character 15: Carination vs V-P Conjunction

This character describes the positioning of the longitudinal aspects of the sagittal lateral keels (blue lines) in relation to conjunction (white circles) of the central vertebral scute sulci (V2, V3, V4) with the respective pleural scutes (P1-P4). In *K. cruentatum* the keels occur moderately exterior to the sulci (blue lines lying exterior to white circles).

Character 15:
Carination vs V-P Conjunction

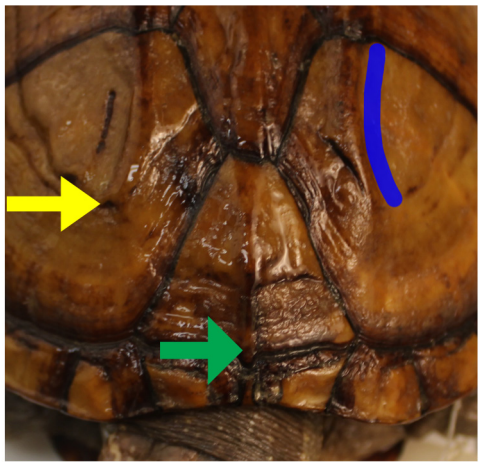
Character 16: Carination Origination P1

This character describes the anterior-to-posterior position on the 1st pleural scute where the lateral carination emerges (yellow arrow). In the model *K. leucostomum*, the lateral carina emerges at the halfway point.

Character 16:
Carination Origination P1

Character 17:
Carination Vector P1

Character 18:
Carination Origination V1



Character 17: Carination Vector P1

This character describes the vector of the lateral carination on the 1st pleural scute (blue line). In the model, the carination diverges away from the midline, in contrast to the carination that converges towards the midline such as in this *K. integrum* complex specimen (right, 2nd image).
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Character 18: Carination Origination V1

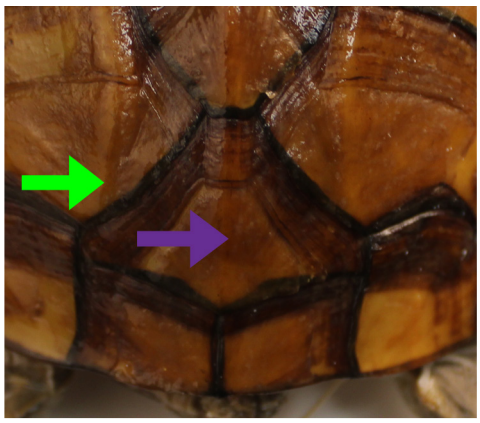
This character describes the anterior-to-posterior position on the 1st vertebral scute where the midline carination emerges (dark green arrow). In the model, the midline carination emerges at the marginal-pleural sulcus.

Character 19a:
Carination Termination P4

Character 19b:
Carination Termination V5

Character 19a: Carination Termination P4

This character describes the anterior-to-posterior position on the 4th pleural scute where the lateral carination terminates (light green arrow). In the model, the lateral carination terminates close to the P4-V5 sulcus, in contrast to the condition in this *K. scorpioides seriei* (right bottom) where the carination terminates at the half way point.



Character 19b: Carination Termination V5

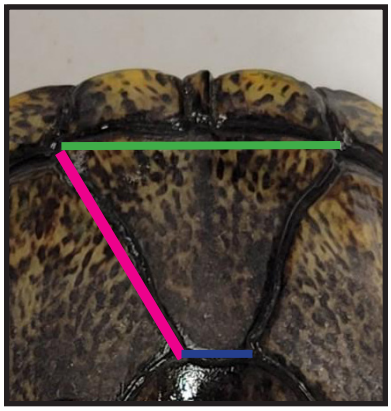
This character describes the anterior-to-posterior position on the 5th vertebral scute where the midline carination terminates (purple arrow). In the model, the midline carination terminates at the half way point, in contrast to the condition in this *K. scorpioides seriei* (right bottom) where the carination terminates at the marginal-pleural sulcus.

Character 20a: V1- P1 Length vs V1 Width

This character describes the ratio of the straight length of the V1-P1 shared sulcus (magenta line), versus the straight width of V1 at its greatest width (green line). In the model of this *K. integrum* complex specimen (right) the ratio factor is .85x.

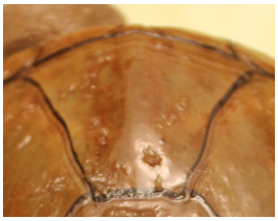
Character 20b: V1- P1 Length vs V1-V2 Width

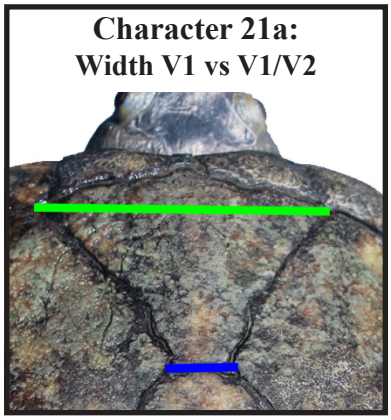
This character describes the ratio of the straight length of the V1-P1 shared sulcus (magenta line), versus the straight width of V1-V2 shared sulcus (blue line). In the model of this *K. integrum* complex specimen (right) the ratio factor is 4.4x.



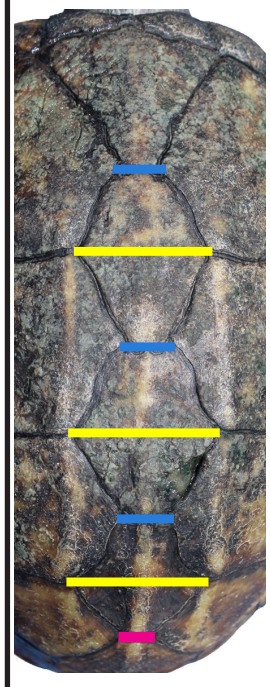
Character 21a: Width V1 vs V1/V2

This character describes the ratio of the width of V1, measured at its greatest width (green line), versus the straight width of the V1-V2 sulcus (blue line). In the model of this *K. albogulare* complex specimen the ratio factor is 4.4x; below, left to right, it is a similar 4.3x in this *K. integrum* complex specimen despite the clearly different shape, and 2.5x in *K. hirtipes tarascense,* and 5.4x in *K. alamosae*.





Character 22a b c: Size of V2 vs V3; V3 vs V4; V2 vs V4



Character 21b - 21e: Width Vertebral vs Intervertebral Sulci

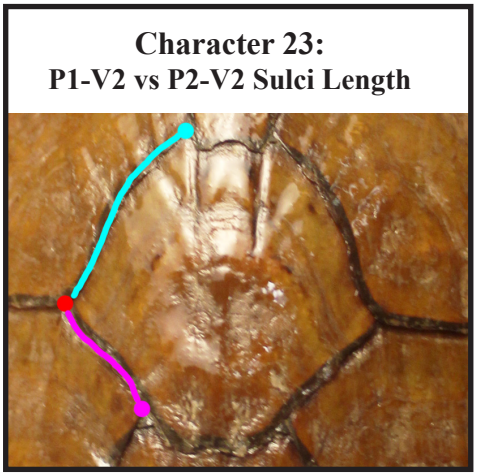
This character describes the ratio of the straight width of each of V2, V3, V4, measured at its greatest width (yellow line), versus the straight width of each of the V1-V2, V2-V3 and V3-V4 sulci (blue line) for characters 21b, 21c, 21d. For 21e, the V4 greatest width (yellow line) is compared against the straight length of the V4-V5 sulcus (magenta line). In the model of this *K. albogulare* complex specimen at left the four respective factors are 2.6x, 2.7x, 2.5x and 4.3x. Below, *K. hirtipes tarascense*, and below right, *K. integrum* are shown for visual comparison.

Character 22a b c: Size of V2 vs V3; V3 vs V4; V2 vs V4

These characters describe the relative shape, respectively, of V2 vs V3; V3 vs V4; V2 vs V4. In this *K. abaxillare* (below, left), V3 is the largest but in this *K. hirtipes tarascense*, center) V3 and V4 are subequal; and below right, *K. integrum* (right) V4 is the largest.

Character 23: P1-V2 vs P2-V2 Sulcus Length

This character describes the relative straight lengths of the P1-V2 Sulcus (light blue line) versus that of the P2-V2 sulcus (magenta line). P1-V2 is measured straight from the V1-V2-P1 conjunction point (light blue dot) to the P1-P2-V2 conjunction point (red dot). P2-V2 is measured straight from the P1-P2-V2 conjunction point (red dot) to the V2-V3-P2 conjunction point (magenta dot). It is modeled here in *K. integrum* (below left) where the P1-V2 sulcus is longer than as seen in this *K. hirtipes tarascense* (below, right).

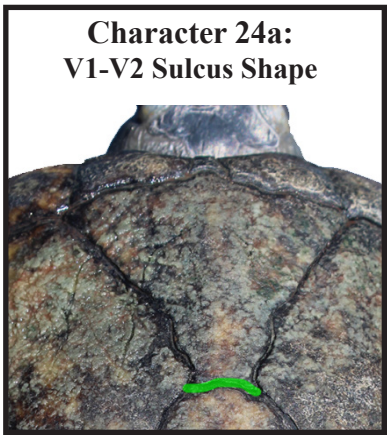


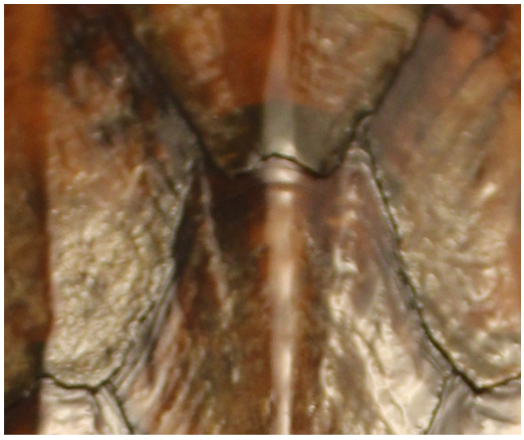
Character 24a: V1-V2 Sulcus Shape

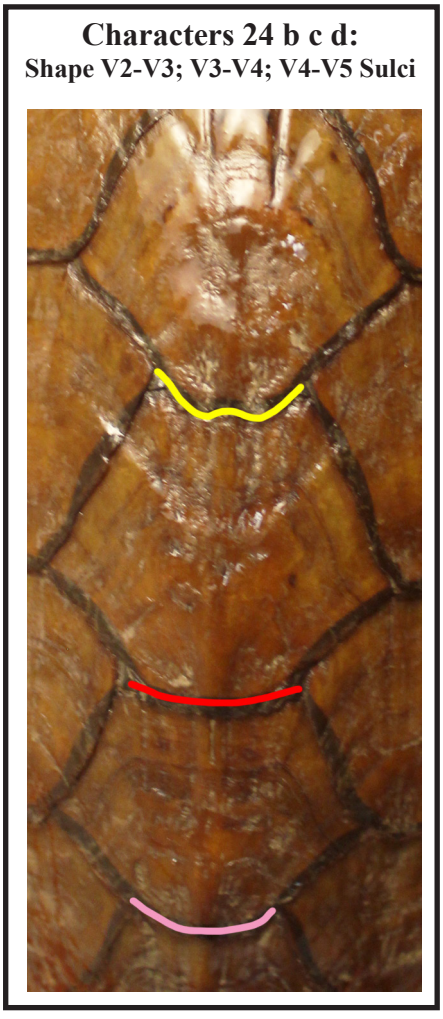
This character describes the shape of the V1-V2 sulcus (green line) where here it is relatively straight in this *K. albogulare* complex specimen (below left), as opposed to below right (*K. scorpioides seriei*).

Character 24 b c d: Shape V2-V3; V3-V4; V4-V5 Sulci

These characters describe the relative shape of the shared sulci of the 2nd, 3rd, 4th and 5th vertebral scutes, respectively, as 27a: V2-V3 sulcus shape (yellow line); 27b: V3-V3 sulcus shape (red line); 27c: V4-V5 sulcus shape (pink line), as illustrated at right in this *K. integrum*. Here 27a (yellow line) is slightly bilobed with 27b (red line) relatively straight and 27c (pink line) slightly posteriorly concave.







Character 25: Nuchal Emargination

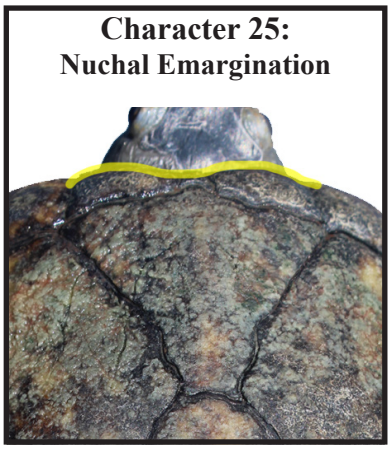
This character describes the degree of the retraction (yellow line) of the anterior most central portion of the carapace (the nuchal bone) from the outline of the adjacent sides. In the model, the emargination is slight; the anterior border of the cervical scute is slightly retracted posteriorly.

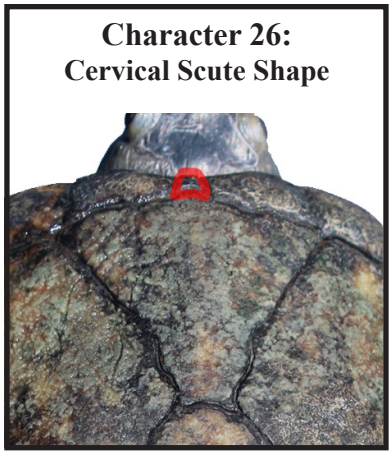
Character 26: Cervical Scute Shape

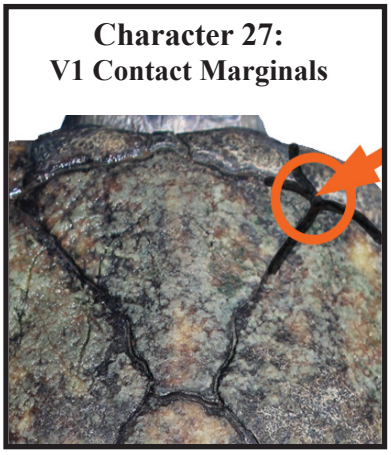
This character describes the shape of the cervical scute (red outline); here it is trapezoidal, with the anterior edge being slightly shorter than the posterior edge.

Character 27: V1 Contact Marginals

This character describes the position on the marginal sulcus where the V1-P1 sulcus contacts the marginal (orange circle with orange arrow). In the model the contact occurs at the M1-M2 sulcus.







Character 28a: Shape of 1st Marginals

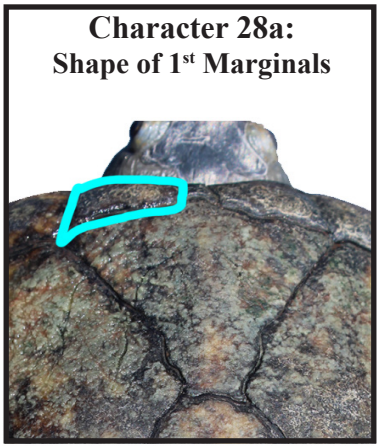
This character describes the shape of the first marginals (M1 – in light blue outline). Here they are asymettrically rectangular.

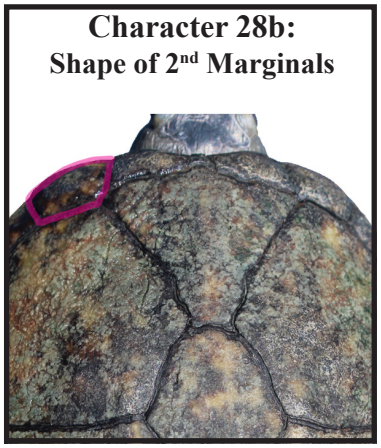
Character 28b: Shape of 2nd Marginals

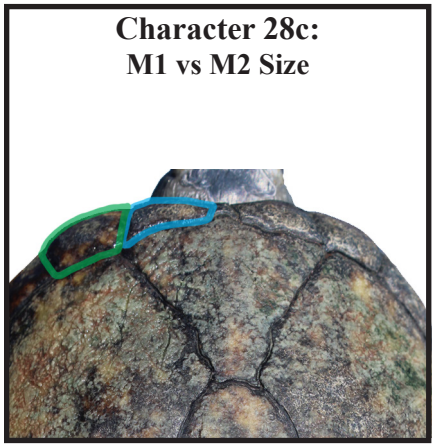
This character describes the shape of the second marginals (M2 – in magenta outline). Here they are squarishly rectangular.

Character 28c: M1 vs M2 Size

This character describes the relative size of M1 (blue outline) to that of M2 (green outline) in dorsal view. Here M1 is smaller than M2.







Character 29: V1-P1 Sulcus Shape

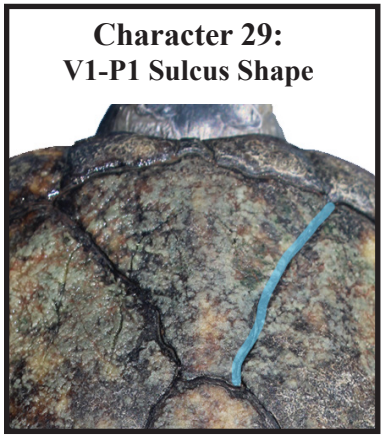
This character describes the relative shape of the V1-P1 sulcus (blue line). Here it is relatively straight in this *K. albogulare* complex specimen as opposed to below where it is sinuous or where it is concave curved.

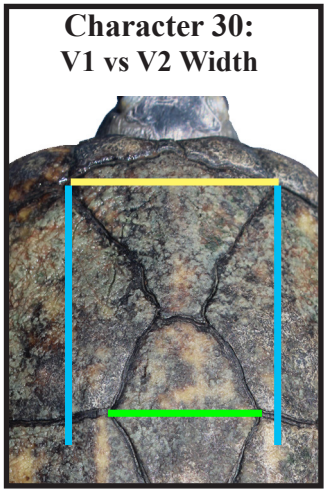
Character 30: V1 vs V2 Width

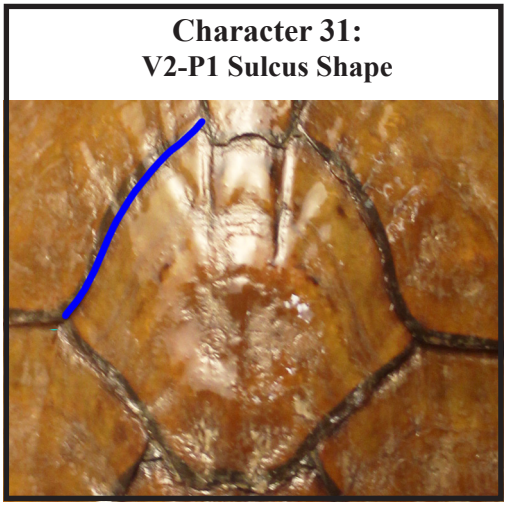
This character describes the ratio of the width of V1, measured at its greatest width (yellow line) vs the greatest width of V2 (green line). In the model V1 is wider, as opposed to where it is subequal and where it is shorter.

Character 31: V2-P1 Sulcus Shape

This character describes the relative shape of the V2-P1 sulcus (dark blue line). Here it is relatively straight as opposed to below where it is strongly convex in this *K. integrum*.





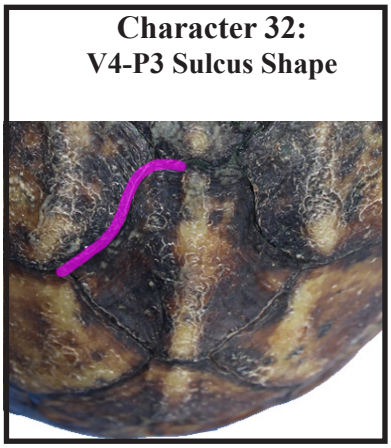


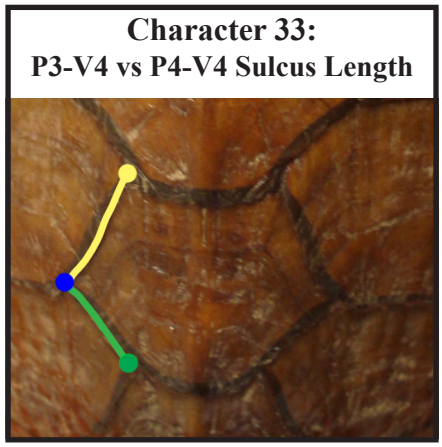
Character 32: V4-P3 Sulcus Shape

This character describes the shape of the V4-P3 sulcus (magenta line); here it is moderately concave towards the midline in this *K. albogulare* complex specimen

Character 33: P3-P4 vs P4-V4 Sulcus Length

This character describes the relative lengths of the P3-V4 Sulcus (yellow line) versus that of the P4-V4 sulcus (green line). P3-V4 is measured straight from the V3-V4-P3 conjunction (yellow dot) to the P3-P4-V4 conjunction (dark blue dot). P4-V4 is measured straight from the P3-P4-V4 conjunction (dark blue dot) to the V4-V5-P4 conjunction (green dot). The sulci here are subequal.



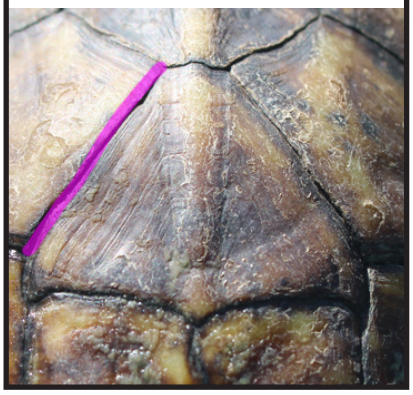


Character 34: V5-P4 Sulcus Shape
This character describes the shape of the V5-P4 sulcus (magenta line) where here it is relatively straight, as opposed to below where it is concave curved and where it is sinuous.

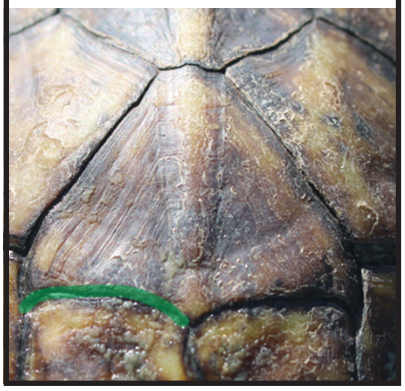
Character 35: M11 Sulcus Shape
This character describes the shape of the M11-V5 sulcus (green line) where here it is convex as opposed to below where it is relatively straight, and where it is sinuous.

Character 36: M11 Shape
This character describes the shape of M11(green outline) where here it is rectangular as opposed to below where it is square and where it is compressed rectangular.

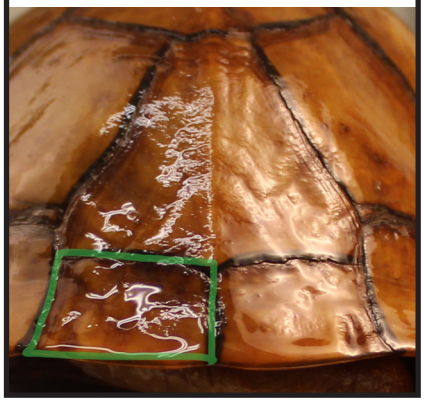
Character 34:
V5-P4 Sulcus Shape



Character 35:
M11 Sulcus Shape



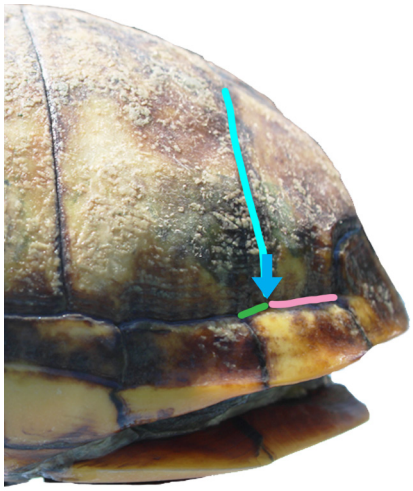
Character 36:
M11 Shape



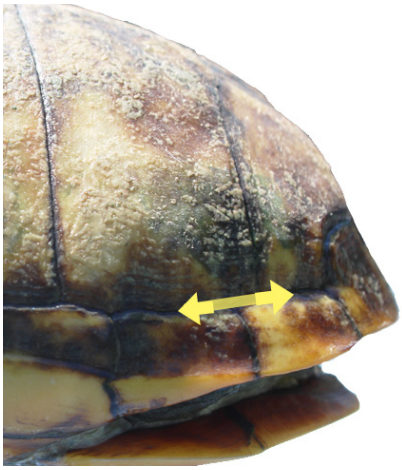
Character 37: P3-P4 Contact M9
This character visually compares the relative point (blue arrow) at which the P3-P4 sulcus (blue line)contacts M9. Here the point is anterior in this *K. albogulare* complex specimen, such that the anterior portion (green line) of the M9 is 1/3 of the length and the posterior portion of M9 (pink line) is 2/3 of the length.

Character 38: M9 vs M8 Height
This character visually compares the relative height of M9 to that of M8 (yellow arrows). Here M9 and M8 are of equal height, whereas in this M9 rises taller than M8.

Character 37:
P3-P4 Contact M9



Character 38:
M9 vs M8 Height

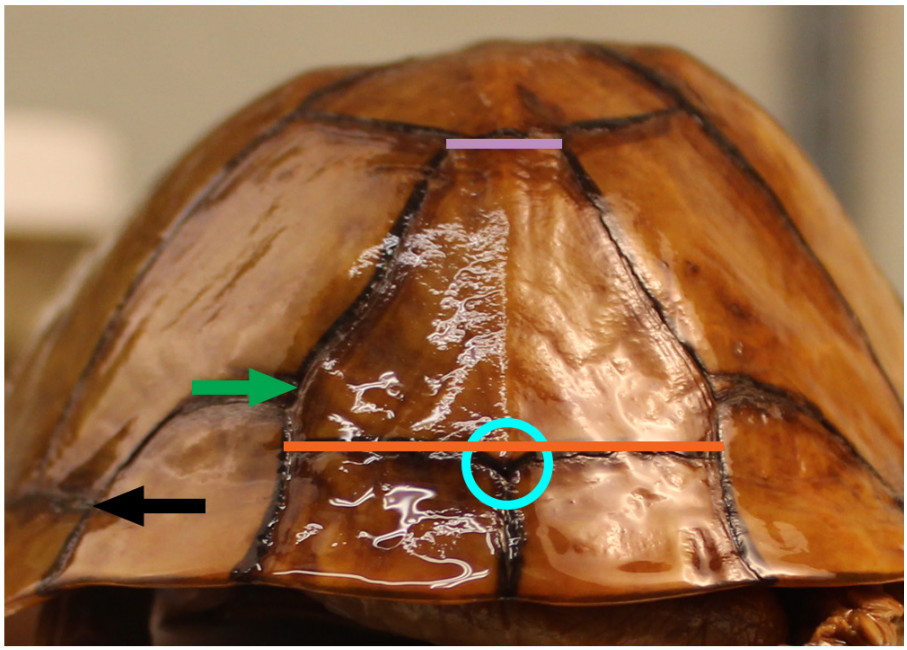


Character 39: M10 vs M9 Height
This character visually compares the relative height of M10 to that of M9 (black arrow). Here M10 strongly rises above adjacent M9 in this *K. panamensis* paratype.

Character 40: M10 vs M11 Height
This character visually compares the relative height of M10 to that of M11 (green arrow). Here M10 strongly rises above adjacent M11.

Character 39:
M10 vs M9 Height

Character 40:
M10 vs M11 Height

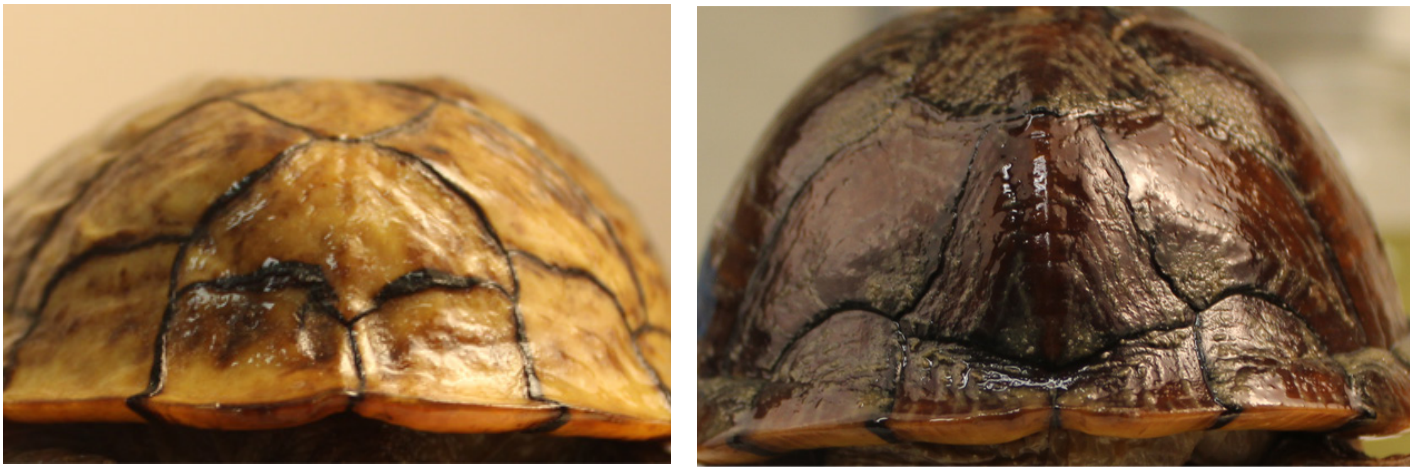


Character 41:
Shape of V5-M11 Midline Sulcus

Character 42:
V5-M11 vs V4-V5 Sulci

Character 41: Shape of V5-M11 Midline Sulcus
This character visually compares the midline sulcus conjunction (blue circle) of V5-M11; here it has a slight posterior dip, whereas it is straight transverse to the midline.

Character 42: V5-M11 vs V4-V5 Sulci
This character expresses the ratio of the V5-M11 combined sulcus (orange line, measured straight transverse to midline) to that of the V4-V5 sulcus (lavender line). Here the ratio if 4x in this *K. panamensis* paratype.



Images of *K. abaxillare* (above left) and *K. leucostomum* (above right) for comparison of Characters 39-42.

Character 43: M10/M11 vs M10/V5 Sulci

This character describes the ratio of the length of M10-M11 shared sulcus (red line) to that of the length of the M10-V5 shared sulcus (green line); here it is 2x in this *K. panamensis* paratype.

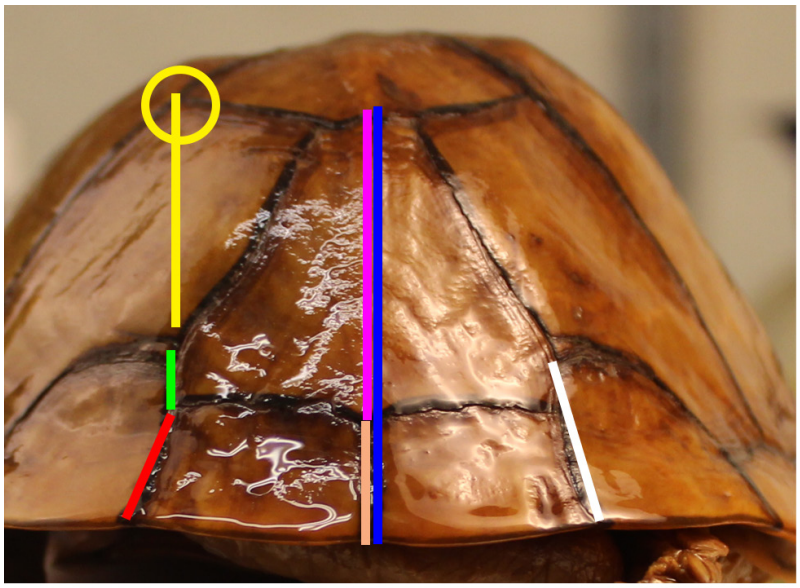
Character 44: V5 Length vs M11 Sulcus

This character describes the ratio of the length of V5 sulcus (magenta line) to that of the length of the M11 shared sulcus (pink line); here it is 2.5x.

Character 43:
M10/M11 vs M10/V5 Sulci

Character 44:
V5 Length vs M11 Sulcus

Character 45:
M10/V5 Sulcus vs V4-P3-P4 Conjunction



Character 47:
M11 Sulcus vs M10/M11 Sulcus

Character 46:
V5/M11 vs M10/M11/V5 Sulcus Length

Character 48:
M10-V5 Sulcus Shape

Character 49:
M10-V5 Sulcus Vector

Character 45: M10/V5 Sulcus vs V4-P3-P4 Conjunction

This character describes the alignment of the M10-V5 Sulcus (green line) in relation to that of the V4-P3-P4 conjunction, viewed in direct on posterior carapace view. Here it lies directly below.

Character 46: V5 /M11 vs M10-M11-V5 Sulcus Length

This character describes the ratio of the length of the V5-M11 combined lengths (measured straight, dark blue line) to that of M10-M11-V5 combined (white line). Here it is 2.5x.

Character 47: M11 Sulcus vs M10/M11 Sulcus

This character describes the relative length of the M11 shared sulcus (pink line) to that of the M10-M11 shared sulcus (red line). Here it is subequal.

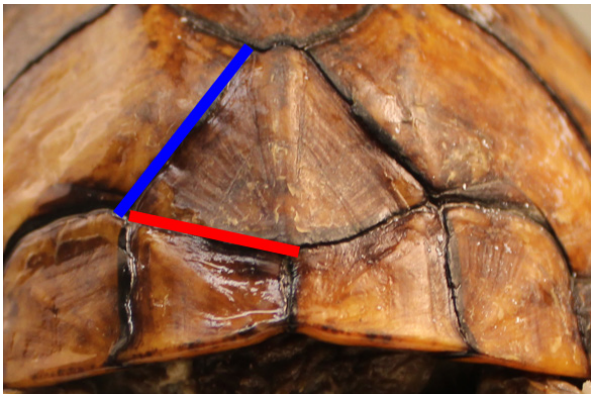
Character 48: M10-V5 Sulcus Shape

This character describes the relative shape of the M10-V5 sulcus (green line), here it is relatively straight.

Character 49: M10-V5 Sulcus Vector

This character describes vector of the M10-V5 sulcus (green line) in relation to the midline, viewed anterior to posterior, when the sulcus is straight in shape (Character 48, above); here is it parallel to the midline.

Character 50:
P4-V5 vs V5-M11 Sulci



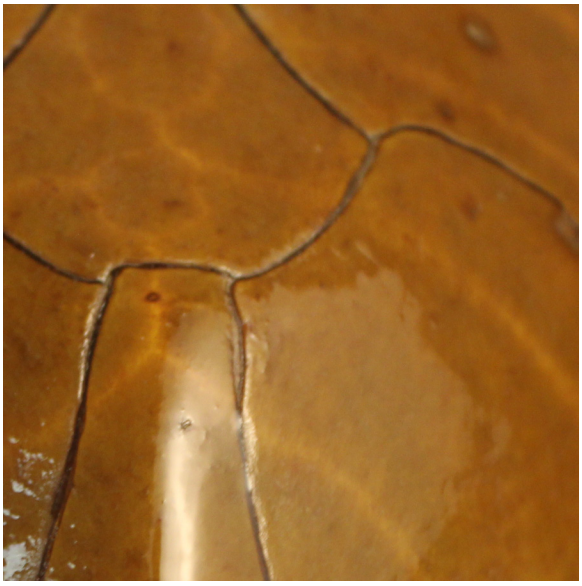
Character 50: P4/V5 + M10/V5 vs V5-M11 Sulci

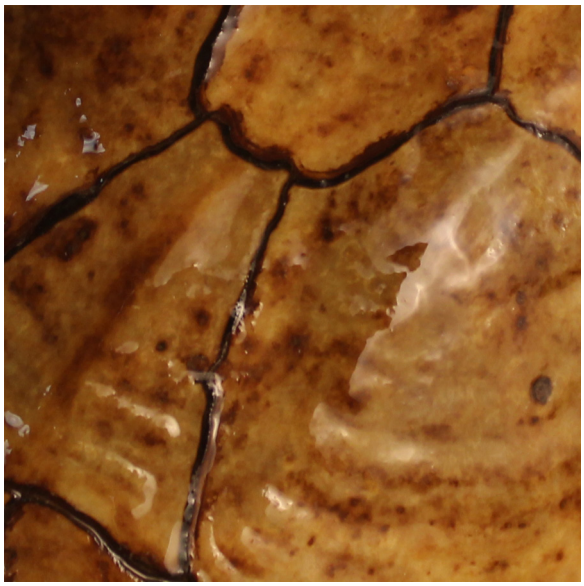
This character describes factor of the combined lengths of the P4/V5 sulcus and M10/V5 (blue line, measured straight) versus that of the straight length of the V5-M11 sulcus. Here in this *K. cruentatum* the factor is 1.25x.

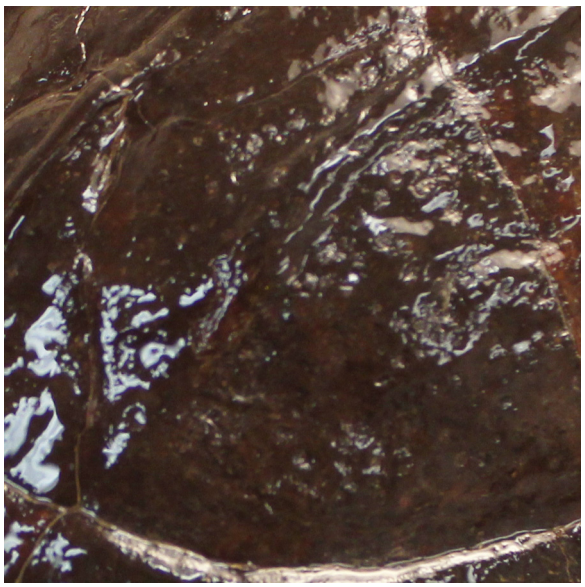
Character 51:
Carapace Sculpture

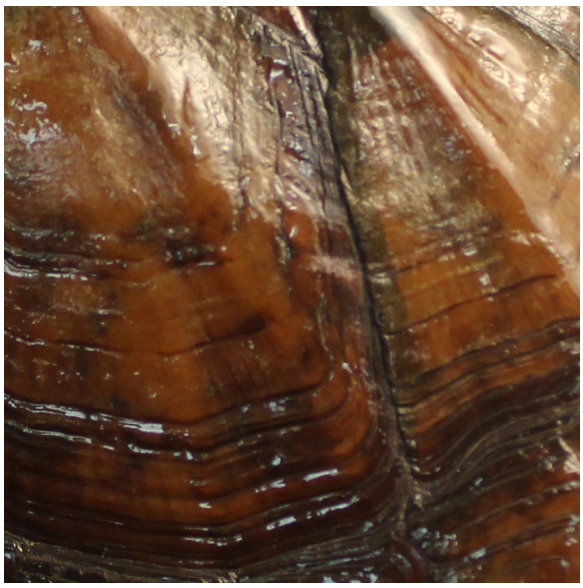
Character 51: Carapace Sculpture

This character describes the texture also known as sculpture of the carapace. Carapace sculpture varies strongly across mud turtle species, as seen here, clockwise from upper left: perfectly smooth in *K. herrerai;* mildly annulated in *K. abaxillare*; annulated in *K. scorpioides seriei* and granulated in *K. oaxacae*.









Characters 52 through 104

Morphology and metrics of the plastron; advanced metrics of the shell.

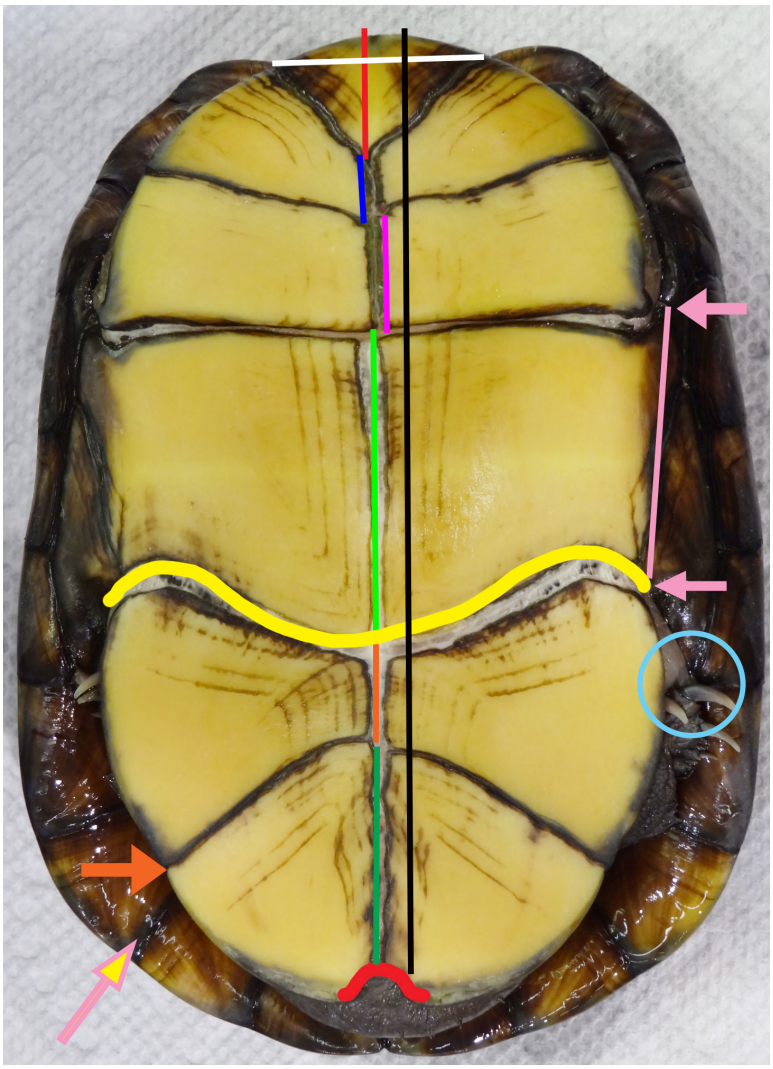
Figure 10. Male (left) and female *Kinosternon alamosae*.

Character 52:
Length Anterior Lobe vs InterPosterohumeral Sulcus

Character 53:
Length Posterior Lobe vs InterPosterohumeral Sulcus

Character 54:
Plastral Midline Sulcus Formulae

Character 55:
Length Anterior vs Posterior Lobes



Character 52: Length Anterior Lobe vs InterPosterohumeral Sulcus
This character describes the relative length of the anterior plastral lobe (red, blue and magenta lines combined) vs that of the interposterohumeral sulcus (light green line). Here it is shorter in this *K. integrum* male.

Character 53: Length Posterior Lobe vs InterPosterohumeral Sulcus
This character describes the relative length of the posterior plastral lobe (orange and dark green lines combined) vs that of the interposterohumeral sulcus (light green line). Here it is shorter.

Character 54: Plastral Midline Sulcus Formulae
His character is expressed as a series of descending relative lengths. In this K. integrum the formulae is IPH > IAn > G > IAH > IF > IG.

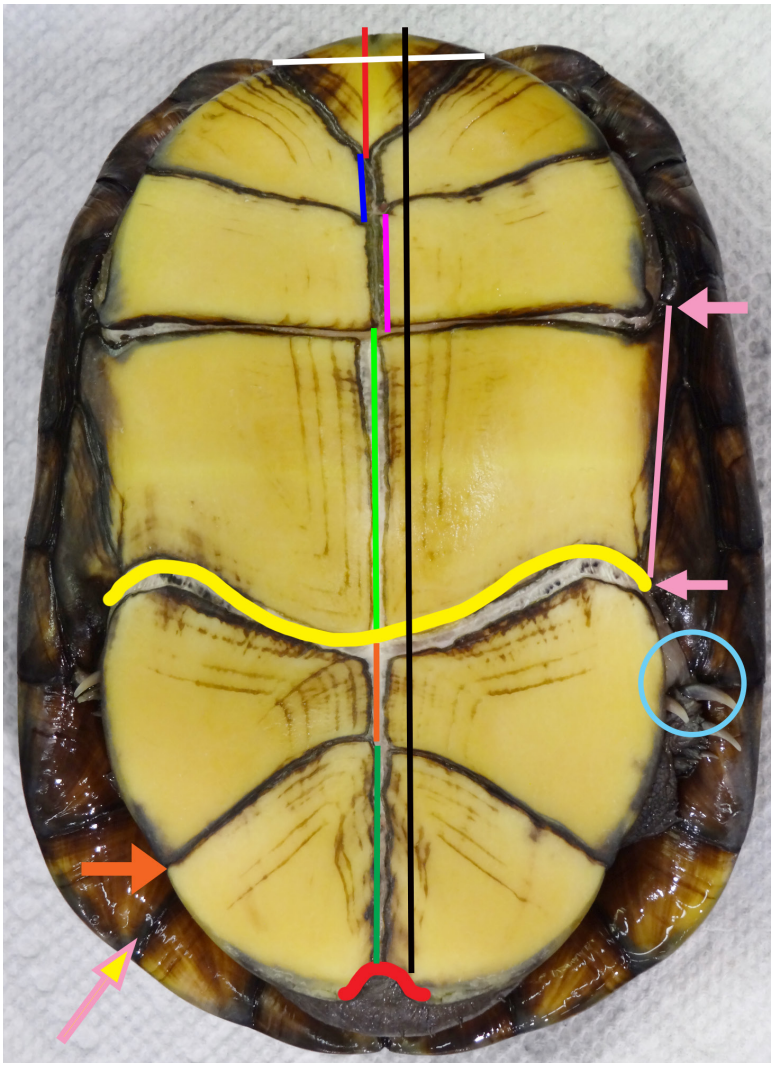
Character 55: Length Anterior vs Posterior Lobes
This character describes the relative length of the anterior plastral lobe (red, blue and magenta lines combined) vs that of the posterior plastral lobe (orange and dark green lines combined). Here it is shorter.

Character 56:
Length vs Intergular Scute Width

Character 57:
Bridge Length vs InterAnal Sulcus

Character 58:
IGSL vs
Intergular/InterAnterohumeral Sulci

Character 59:
Inguinal vs Antero Posterior Lobe



Character 56: Length vs Intergular Scute Width
This character describes the relative length of the Intergular Scute (red line =IGSL) to that of the width (white line). Here it is shorter.

Character 57: Bridge Length vs InterAnal Sulcus
This character compares the relative length of the bridge (pink line) vs that of the Interanal Sulcus (dark green line). The bridge is measured straight from the posteriormost point of the axillary notch (top pink line) to the anterior-most point of the inguinal notch (bottom pink line). Bridge is longer than IAn in this *K. integrum*.

Character 58: IGSL vs Intergular/InterAnterohumeral Sulci
This character compares the intergular scute straight length (red line) to that of the combined intergular/ interant-erohumeral sulci (dark blue plus magenta lines) relatively. Here it is shorter.

Character 59: Inguinal vs Antero Posterior Lobe
This character describes the relative position of the point where the inguinal scute terminates (blue circle) to that of the posterior plastral hinge (bottom pink arrow). Here it is strongly posterior.

Character 60:
Inter-Femoral-Anal Sulcus vs Marginal

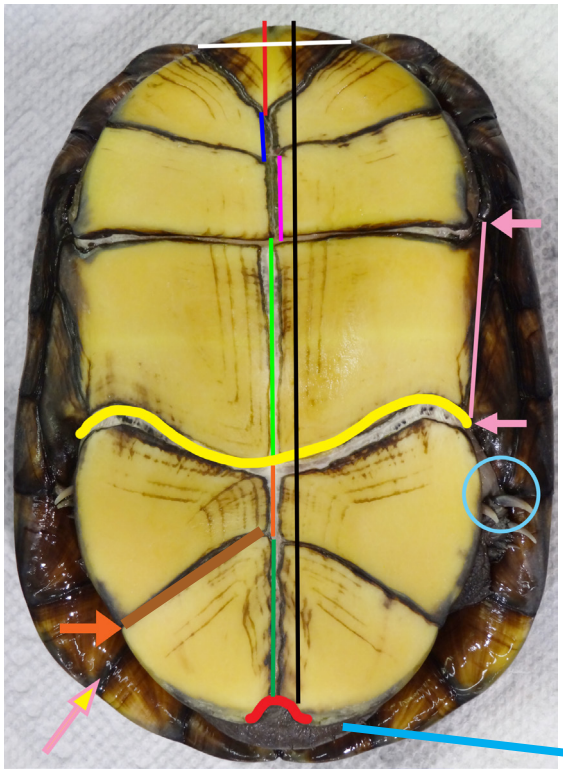
Character 61a:
Anal Scute Notch

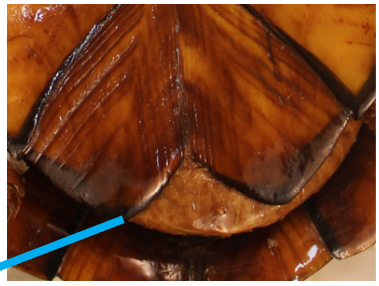
Character 61b:
Anal Scute Tip Shape

Character 62a:
InterAnal vs
InterPosterohumeral Sulcus

Character 62b:
InterAnal vs
Inter-Femoral-Anal Sulcus

Character 63:
Shape of Posterior Plastral Hinge





Character 60: Inter-Femoral-Anal Sulcus vs Marginal
This character describes the relative position of the exteriormost point of the inter-femoral-anal sulcus (orange arrow) to that of the M9-M10 shared sulcus (pink yellow arrow) when the posterior plastral lobe is flat. Here it is anterior of the sulcusin this *K integrum*.

Character 61a: Anal Scute Notch
This character describes the relative emargination of the posterior plastral lobe (the anal scute notch, thick red curve). Here it is considered moderate.

Character 61b: Anal Scute Tip Shape
This character describes the shape of the anal scute tip (light blue line, the posterior most point of the plastron). Here it is considered shallowly round but in the *K stejnegeri* at top right, the tips are clearly triangular.

Character 62a: InterAnal vs InterPosterohumeral Sulcus
This character describes the factor of the Interanal sulcus (dark green line) to that of the interposterohumeral sulcus (light green line).

Character 62b: InterAnal vs Inter-Femoral-Anal Sulcus
This character describes the relative length of the InterAnal sulcus (dark green line) to that of the inter-femoral-anal shared sulcus (light brown line).

Character 63: Shape of Posterior Plastral Hinge
This character describes the shape of the posterior plastral hinge (yellow line). Here it is sinuous with posterior concavity.

Character 64a:
Plastral Coverage

This character describes the coverage of the plastron against the ventral opening of the shell (light blue shading, in part, versus the plastron). In this *K. herrerai,* the plastron cannot close the ventral opening in the entirety (i.e. the head, limbs and tail cannot all be concealed by the plastral lobes when closed, or fixed as posterior lobe is in this species).

Character 64b:
Axillary Notch Opening

This character describes the degree to which the axillary notch is a component of the opening of the antero-middle plastral venter. It is calculated as the ratio of the width of the ventral shell (as measured perpendicular to the middle line) from the interior point of the ventral marginals (green line, from green dot to green dot) at the level of the anterior plastral hinge, versus the width of the anterior plastral hinge (red line). In this *K. herrerai* it is .83 (e.g. the axillary notch constitutes 17% of the antero-middle venter).

Character 64c:
Inguinal Notch Opening

This character describes the degree to which the inguinal notch is a component of the opening of the postero-middle plastral venter. It is calculated as the ratio of the width of the ventral shell (as measured perpendicular to the middle line) from the interior point of the ventral marginals at the posterior most point of the inguinal scute (white line, from white dot to white dot) versus the width of the posterior plastral hinge (light blue line) measured at the same level. In this *K. herrerai* it is .72 (e.g. the inguinal notch constitutes 28% of the postero-middle venter).

Character 64d:
Inguinal Notch vs Posterior Hinge

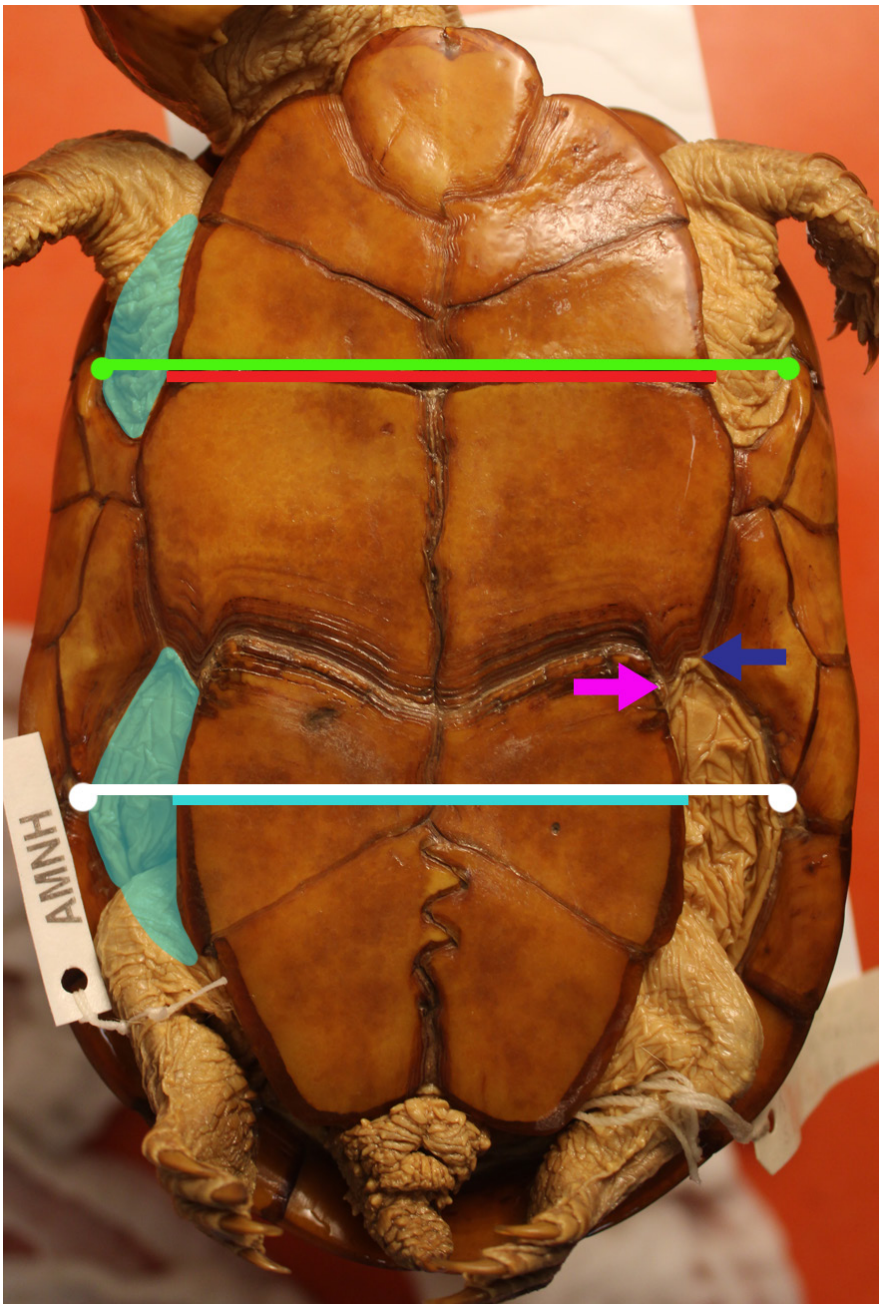
This character describes the positional relationship of the anterior most point of the inguinal notch (dark blue arrow) versus that of the exteriormost point of the posterior plastral hinge (magenta arrow). Here it lies anterior.

Character 64a:
Plastral Coverage

Character 64b:
Axillary Notch Opening

Character 64c:
Inguinal Notch Opening

Character 64d:
Inguinal Notch vs Posterior Hinge



Character 65: Carapace Length vs Anterior Length
This character describes the ratio (factor) of the Carapace Length (yellow line) versus that of the Anterior Plastral Lobe (green line). Here it is 3.3x.

Character 66: Carapace Length vs Fixed Length
This character describes the ratio (factor) of the Carapace Length (yellow line) versus that of the Fixed Plastral portion (magenta line). Here it is 3.2x.

Character 67: Carapace Length vs Posterior Length
This character describes the ratio (factor) of the Carapace Length (yellow line) versus that of the Posterior Plastral Lobe (orange line). Here it is 3.1x.

Character 68: Carapace Width vs Anterior Length
This character describes the ratio (factor) of the Carapace Width (purple line) versus that of the Anterior Plastral Lobe (green line). Here it is 2.5x.

Character 69: Carapace Width vs Fixed Length
This character describes the ratio (factor) of the Carapace Width (purple line) versus that of the Fixed Plastral portion (magenta line). Here it is 2.4x.

Character 70: Carapace Width vs Posterior Length
This character describes the ratio (factor) of the Carapace Width (purple line) versus that of the Posterior Plastral Lobe (orange line). Here it is 2.3x.

Character 71: Plastral Lobe Formulae
This character describes the comparative lengths of the 3 portions of the plastron (anterior lobe, fixed center and posterior lobe). Here it is Posterior> Fixed> Anterior.

Character 65:
Carapace Length vs Anterior Length

Character 66:
Carapace Length vs Fixed Length

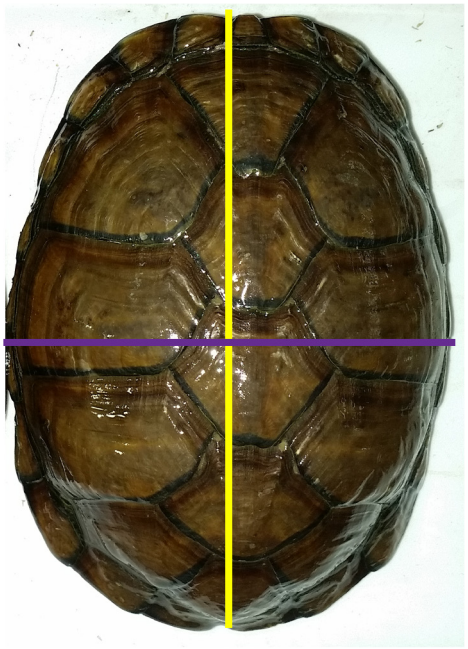
Character 67:
Carpace Length vs Posterior Length

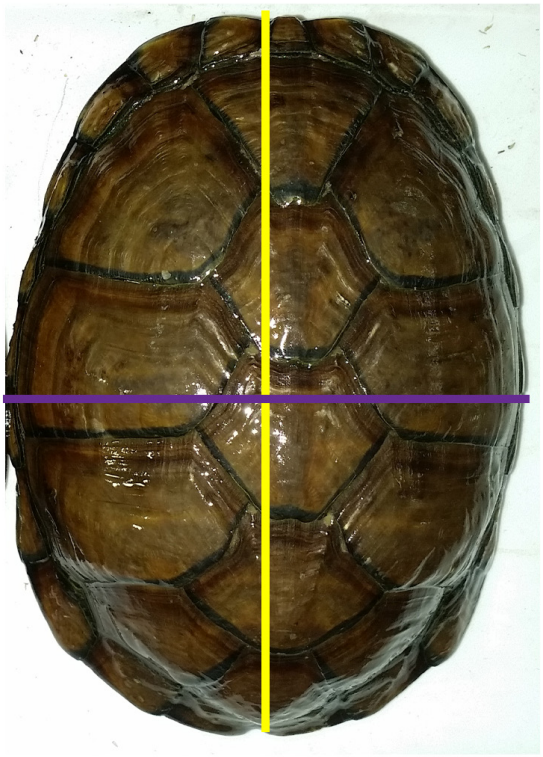
Character 68:
Carapace Width vs Anterior Length

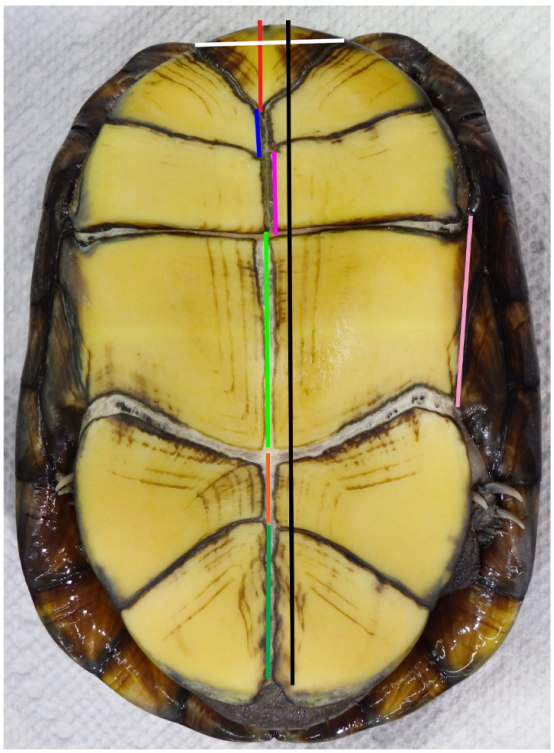
Character 69:
Carapace Width vs Fixed Length

Character 70:
Carapace Width vs Posterior Length

Character 71:
Plastral Lobe Formulae







Character 72a:
Carapace Length vs
Intergular Scute Length

Character 72b:
Carapace Length vs
Intergular Sulcus Length

Character 72c:
Carapace Length vs
Interanterohumeral Length

Character 72d:
Carapace Length vs
Interposterohumeral Length

Character 72e:
Carapace Length vs
Interfemoral Length

Character 72f:
Crapace Length vs
Interanal Length

Character 72a: Carapace Length versus Intergular Scute Length
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the length of the Intergular Scute (measured straight anterior to posterior, red line).

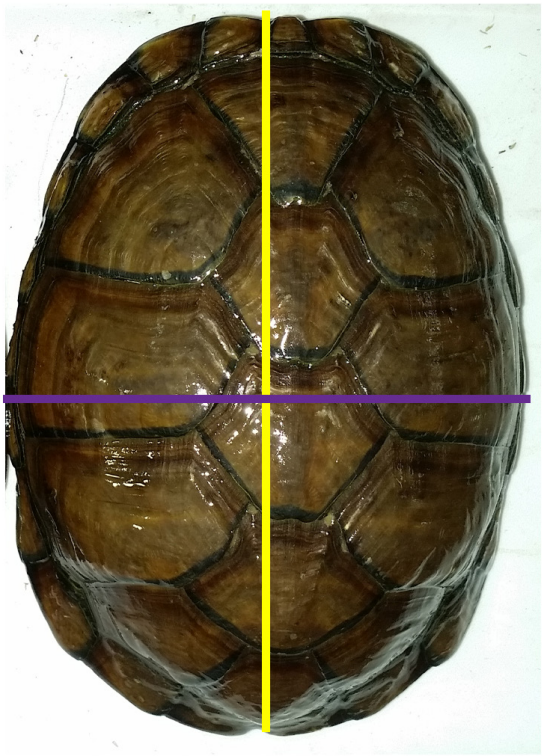
Character 72b: Carapace Length versus Intergular Sulcus Length
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the Intergular Sulcus Length (measured straight anterior to posterior, blue line).

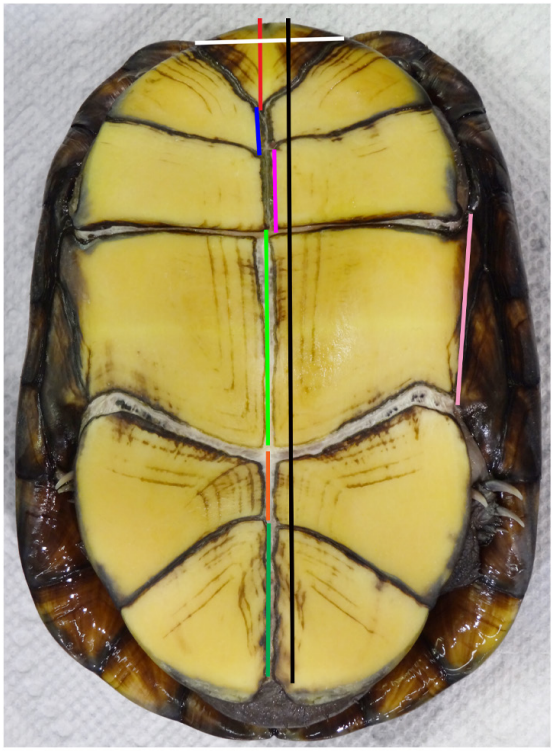
Character 72c: Carapace Length versus Interanterohumeral Length
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the Interanterohumeral Sulcus Length (measured straight anterior to posterior, lavender line).

Character 72d: Carapace Length versus Interposterohumeral Length
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the Interposterohumeral Sulcus Length (measured straight anterior to posterior, light green line).

Character 72e: Carapace Length versus Interfemoral Length
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the Interfemoral Sulcus Length (measured straight anterior to posterior, orange line).

Character 72f: Carapace Length versus Interanal Length
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the Interanal Sulcus Length (measured straight anterior to posterior, dark green line).





Character 73:
Carapace Length vs Bridge Length

Character 74:
Carapace Length vs Plastron Length

Character 75:
Carapace Width vs Plastron Length

Character 76:
Carapace Width vs Intergular Scute Width

Character 77:
Carapace Width vs Bridge Length

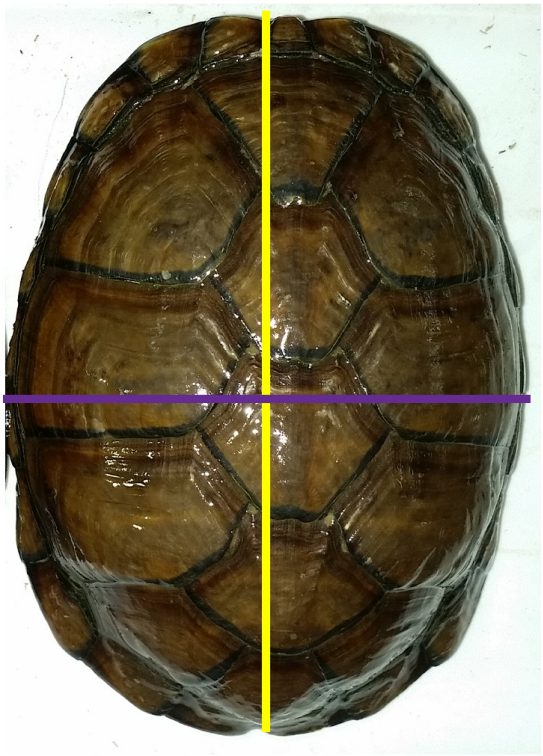
Character 73: Carapace Length versus Bridge Length
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the Bridge Length (pink line). Bridge length is measured straight anterior to posterior from the posteriormost point of the axillary notch to the anteriormost point of the inguinal notch.

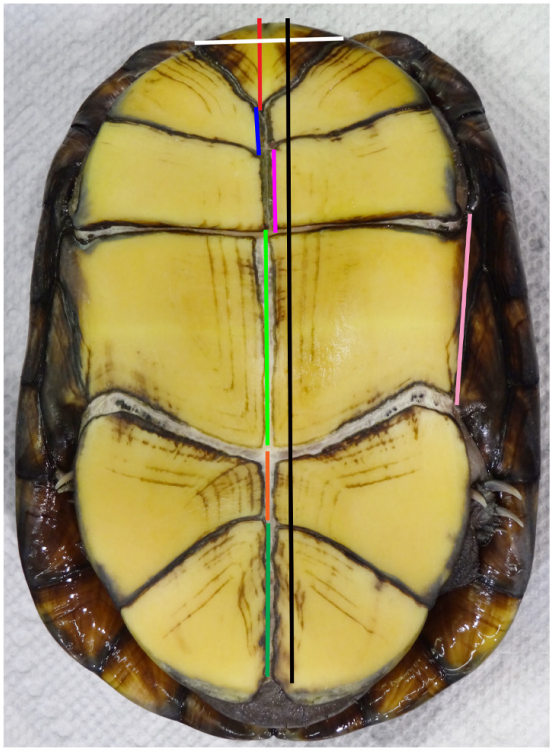
Character 74: Carapace Length versus Plastron Length
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the Plastron Length (black line, measured straight anterior to posterior down the midline).

Character 75: Carapace Width versus Plastron Length
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the Plastron Length (black line, measured straight anterior to posterior down the midline).

Character 76: Carapace Width versus Intergular Scute Width
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the width of the Intergular Scute (white line, measured straight at points of greatest width).

Character 77: Carapace Width versus Bridge Length
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the Bridge Length (pink line). Bridge length is measured straight anterior to posterior from the posteriormost point of the axillary notch to the anteriormost point of the inguinal notch.





Character 78a:
Carpace Width vs
Intergular Scute Length

Character 78b:
Carapace Width vs
Intergular Sulcus Length

Character 78c:
Carapace Width vs
Interanterohumeral Length

Character 78d:
Carapace Width vs
Interposterohumeral Length

Character 78e:
Carapace Width vs
Interfemoral Length

Character 78f:
Carapace Width vs
Interanal Length

Character 78a: Carapace Width versus Intergular Scute Length
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the length of the Intergular Scute (measured straight anterior to posterior, red line).

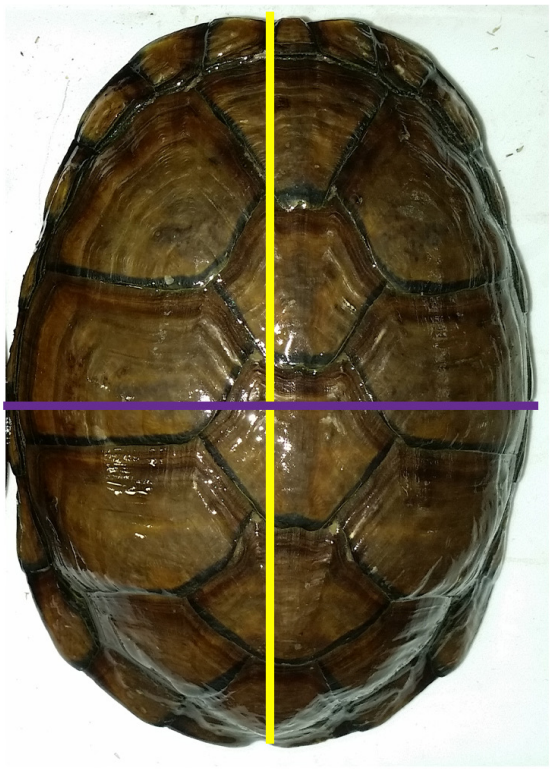
Character 78b: Carapace Width versus Intergular Sulcus Length
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the Intergular Sulcus Length (measured straight anterior to posterior, blue line).

Character 78c: Carapace Width versus Interanterohumeral Length
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the Interanterohumeral Sulcus Length (measured straight anterior to posterior, lavender line).

Character 78d: Carapace Width versus Interposterohumeral Length
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the Interposterohumeral Sulcus Length (measured straight anterior to posterior, light green line).

Character 78e: Carapace Width versus Interfemoral Length
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the Interfemoral Sulcus Length (measured straight anterior to posterior, orange line).

Character 78f: Carapace Width versus Interanal Length
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the Interanal Sulcus Length (measured straight anterior to posterior, dark green line).



Character 79a: Carapace Length vs Anterior Lobe A

Character 79b: Carapace Length vs Anterior Lobe B

Character 80a: Carapace Length vs Fixed Lobe A

Character 80b: Carapace Length vs Fixed Lobe B

Character 81a: Carapace Length vs Posterior Lobe A

Character 81b: Carapace Length vs Posterior Lobe B

Character 79a: Carapace Length versus Anterior Lobe A
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the width of the anterior portion of the anterior plastral lobe (orange line, measured across the level of the exterior points of the shared sulcus of the gular-anterohumeral scutes).

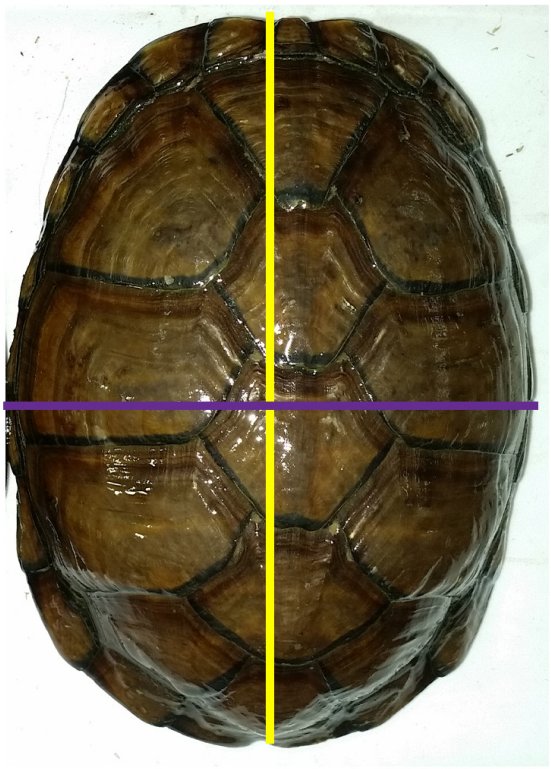
Character 79b: Carapace Length versus Anterior Lobe B
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the width of the posterior portion of the anterior plastral lobe (green line, measured across the level of the exterior points of posteriormost anterohumeral scutes).

Character 80a: Carapace Length versus Fixed Lobe A
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the width of the anterior portion of the fixed plastral lobe (lavender line, measured across the level of the exterior points of anteriormost posterohumeral scutes).

Character 80b: Carapace Length versus Fixed Lobe B
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the width of the posterior portion of the fixed plastral lobe (white line, measured across the level of the exterior points of posteriormost posterohumeral scutes).

Character 81a: Carapace Length versus Posterior Lobe A
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the width of the posterior plastral lobe (peach line, measured across the level of the widest point; here the exterior middle femoral scutes).

Character 81b: Carapace Length versus Posterior Lobe B
This character measures the factor of the Carapace Length (measured straight length, down midline, yellow line) to that of the width of the posterior plastral lobe (brown line, measured across the level of the exterior points of the shared sulcus of the femoral-anal scutes).



Character 82a:
Carapace Width vs Anterior Lobe A

Character 82b:
Carapace Width vs Anterior Lobe B

Character 83a:
Carapace Width vs Fixed A

Character 83b:
Carapace Width vs Fixed B

Character 84a:
Carapace Width vs Posterior Lobe A

Character 84b:
Carapace Width vs Posterior Lobe B

Character 82a: Carapace Width versus Anterior Lobe A
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the width of the anterior portion of the anterior plastral lobe (orange line, measured across the level of the exterior points of the shared sulcus of the gular-anterohumeral scutes).

Character 82b: Carapace Width versus Anterior Lobe B
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the width of the posterior portion of the anterior plastral lobe (green line, measured across the level of the exterior points of posteriormost anterohumeral scutes).

Character 83a: Carapace Width versus Fixed A
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the width of the anterior portion of the fixed plastral lobe (lavender line, measured across the level of the exterior points of anteriormost posterohumeral scutes).

Character 83b: Carapace Width versus Fixed B
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the width of the posterior portion of the fixed plastral lobe (white line, measured across the level of the exterior points of posteriormost posterohumeral scutes).

Character 84a: Carapace Width versus Posterior Lobe A
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the width of the posterior plastral lobe (peach line, measured across the level of the widest point; here the exterior middle femoral scutes).

Character 84b: Carapace Width versus Posterior Lobe B
This character measures the factor of the Carapace Width (measured perpendicular to the midline at widest carapace point, purple line) to that of the width of the posterior plastral lobe (brown line, measured across the level of the exterior points of the shared sulcus of the femoral-anal scutes).

Character 85a:
Anterior Hinge vs Fixed Width
This character describes the ratio of the antero-Anterior plastral lobe hinge width (light blue line) to that of the width of the postero-Anterior Plastral Lobe Hinge (Dark Green Line) measured at the anterior most portion of the Posterohumeral scute where it meets the axillary scute (measured straight perpendicular to midline)

Character 85b:
Anterior Hinge vs Posterior Hinge Width
This character describes the ratio of the anterior plastral lobe hinge width (dark green line) to that of the posterior plastral lobe hinge (red line).

Character 86:
Anterior Hinge Width vs Interposterohumeral Sulcus
This character describes the ratio of the width of the anterior plastral lobe hinge (dark green line) to that of the interposterohumeral sulcus (black line).

Character 87:
Posterior Hinge Width vs Interposterohumeral Sulcus
This character describes the ratio of the width of the posterior plastral lobe hinge (red line) to that of the interposterohumeral sulcus (black line).

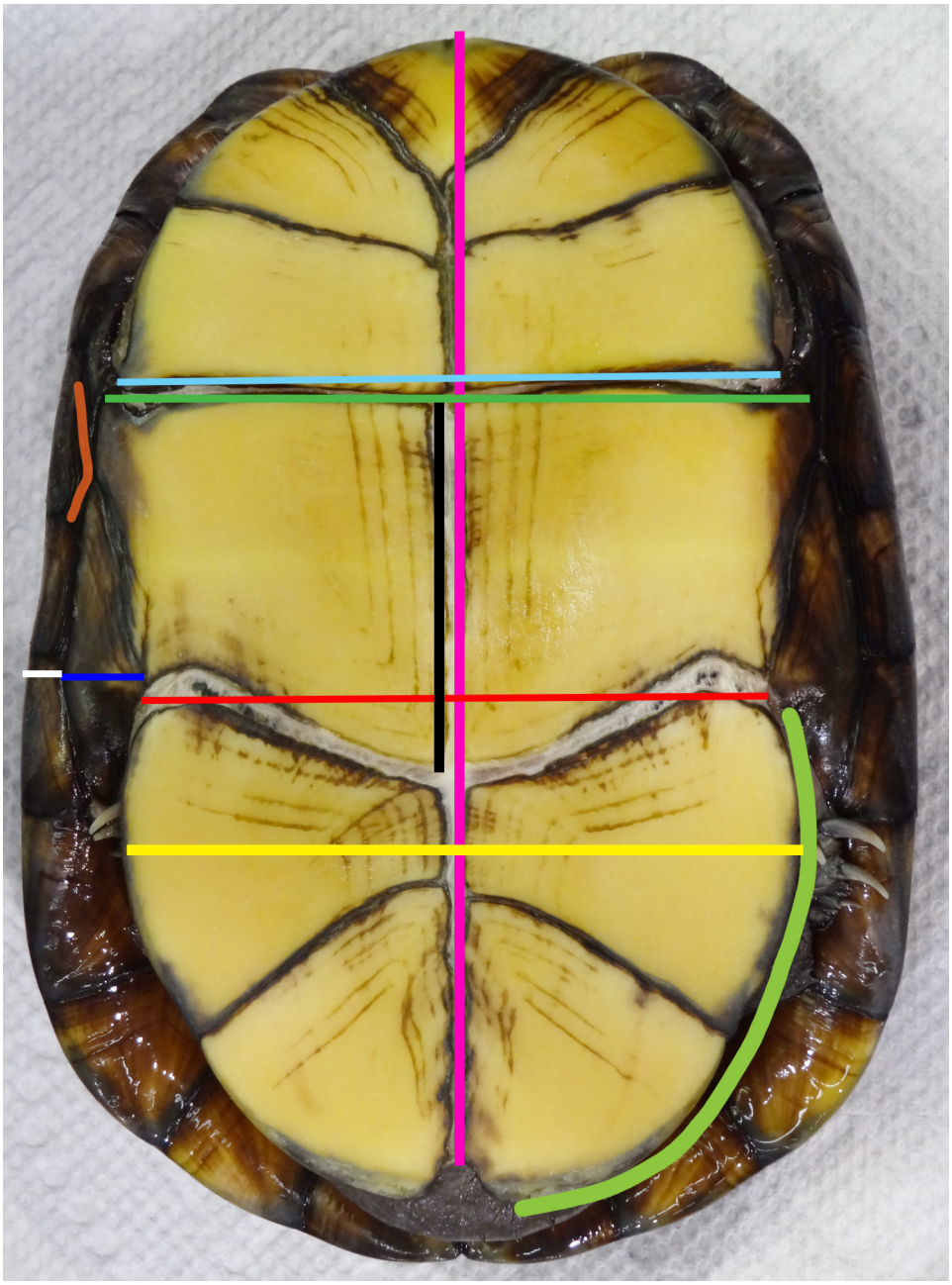
Character 88a:
Plastral Midline Length vs Antero-Anterior Plastral Lobe Hinge
This character describes the ratio of the Plastral Midline Length (Magenta Line) to that of the width of the antero-Anterior Plastral Lobe Hinge (light blue line).

Character 88b:
Plastral Midline Length vs Anterior Hinge Width Fixed
This character describes the ratio of the Plastral Midline Length (Magenta Line) to that of the width of the Anterior Plastral Lobe Hinge (dark green line) measured at the anterior most portion of the Posterohumeral scute where it meets the axillary scute (measured straight perpendicular to midline).

Character 85a:
Antero-Anterior Hinge Lobe Width vs Anterior Lobe Hinge

Character 85b:
Anterior Hinge vs Posterior Hinge Width

Character 86:
Anterior Hinge Width vs Interposterohumeral Sulcus



Character 87:
Posterior Hinge Width vs Interposterohumeral Sulcus

Character 88a:
Plastral Midline Length vs Antero-Anterior Hinge Lobe Width

Character 88b:
Plastral Midline Length vs Anterior Hinge Width Fixed

Character 88c:
Plastral Midline Length vs Posterior Hinge Width

This character describes the ratio of the Plastral Midline Length (Magenta Line) to that of the width of the posterior plastral lobe hinge (red line).

Character 89:
Plastral Midline Length vs Femoral Width

This character describes the ratio of the Plastral Midline Length (Magenta Line) to that of the Width of the Femoral Scutes at the widest point (Yellow Line).

Character 90:
Width of Inguinal vs Adjacent Marginal

This character describes the ratio of the inguinal scute width (dark blue line) at its widest value to that of the width of the adjacent marginal at the same level (white line).

Character 91:
Shape of Exterior Plastral Lobe

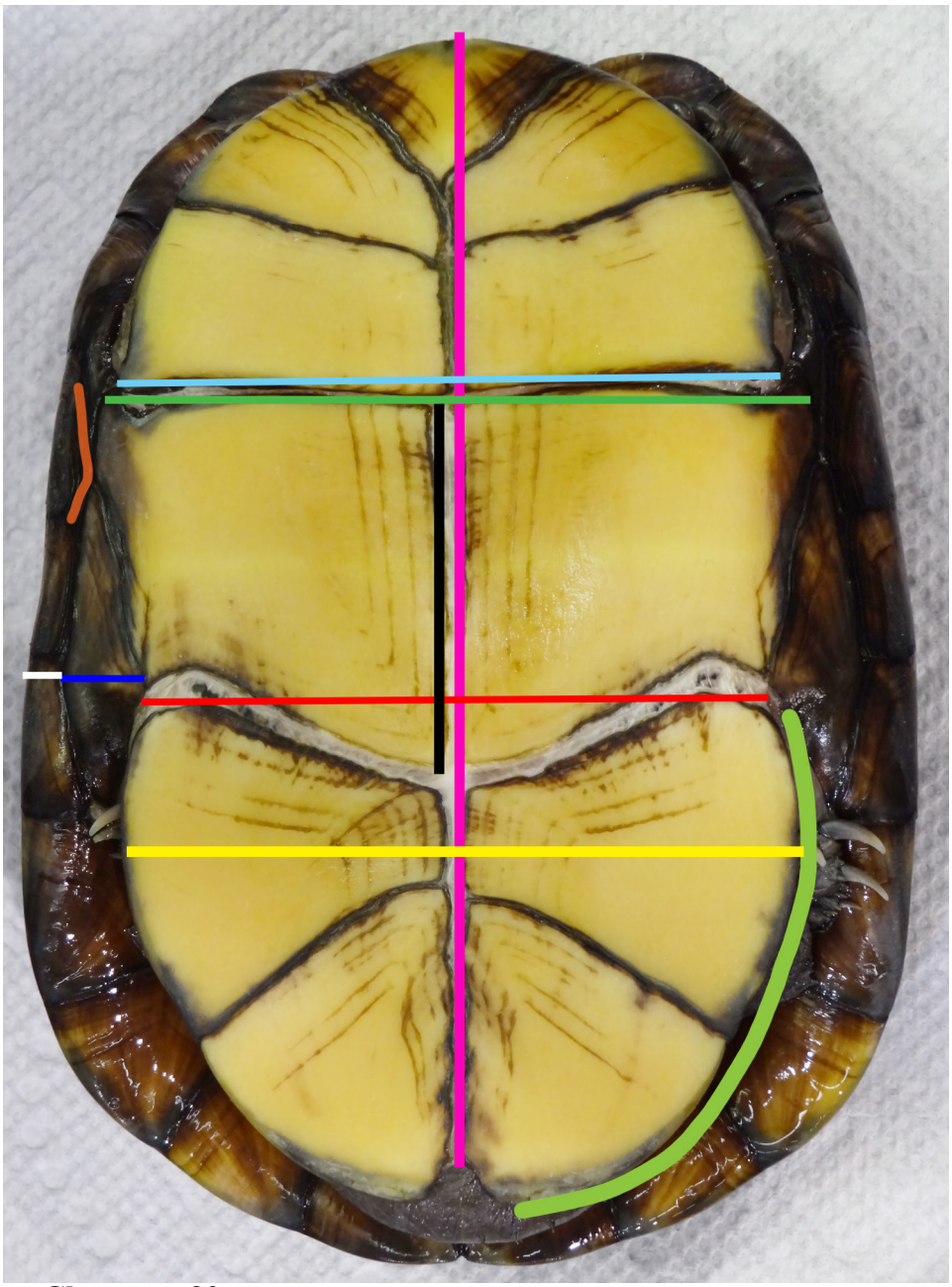
This character describes the relatively shape of the exterior rim of the posterior plastral lobe. Typical states include circular, semi-circular and truncated.

Character 92:
M5 Expansion

This character describes the degree to which the 5th marginal scute sulcus pinhes against the bridge (orange angle). There are two states:
in this *K. integrum* is the typical state. In *K. scorpioides* complex specimen the sulcus becomes so acute as to visibly compress the axillary-inguinal scutes against the posterohumeral scute (bottom right, orange line).

Character 88c:
Plastral Midline Length vs Posterior Hinge Width

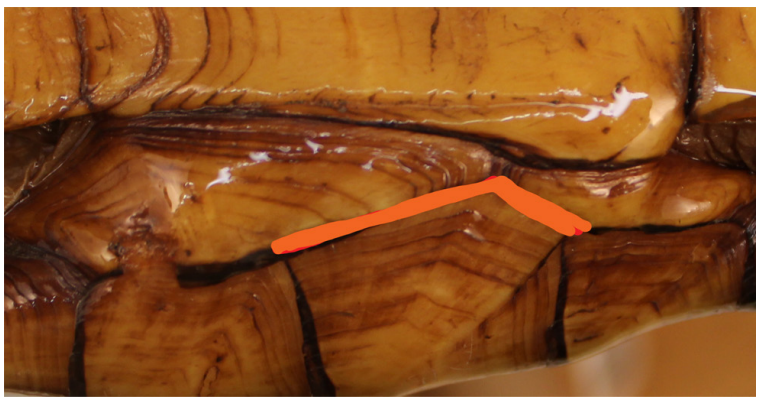
Character 89:
Plastral Midline Length vs Femoral Width



Character 90:
Width of Inguinal vs Adjacent Marginal

Character 91:
Shape of Exterior Plastral Lobe

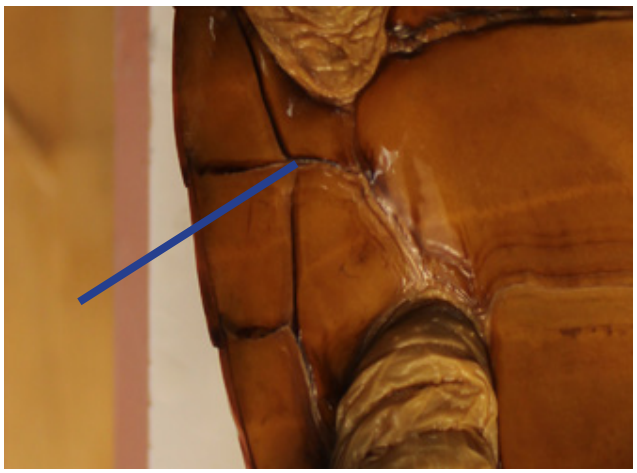
Character 92:
M5 Expansion



Character 93a:
Marginal Start Axillary
This character describes the position of the start (anterior – yellow arrow) of the axillary scute (red line) against the marginal. Here it contacts M4 at the midpoint.

Character 93b:
Marginal End Axillary
This character describes the position of the end (posterior – green arrow) of the axillary scute (red line) against the marginal. Here it contacts M5 at the midpoint.

Character 94a:
Axillary Inguinal Contact
This character visual describes the contact (or absence of, light blue line) of the posterior terminus of the axillary scute with the anterior start of the inguinal scute. Here no contact occurs at right, but is pointed contact in this and broadly truncated in contact in this *K. herrerai* below.



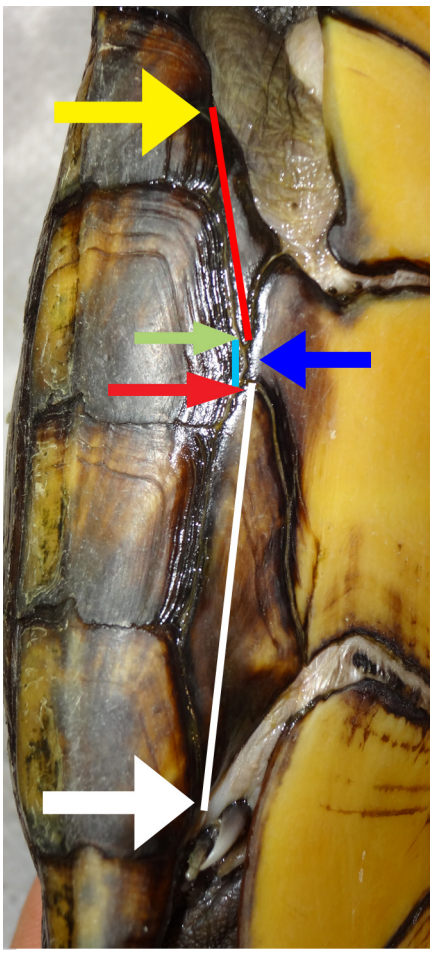
Character 94b:
Axillary-Inguinal Gap
When a gap is present (no axillary-inguinal contact, light blue line), this character describes the ratio of the length of the axillary scute (red line) vs that of the length of the gap (light blue line). Here it is 7x.

Character 95a:
Marginal Start Inguinal
This character describes the position of the start (anterior – red arrow) of the inguinal scute (white line) against the marginal. Here it contacts M5 at the posterior 2/3 point.

Character 95b:
Marginal End Inguinal
This character describes the position of the end (posterior – white arrow) of the inguinal scute (white line) against the marginal. Here it contacts M7 at the posterior 2/3 point.

Character 93a:
Marginal Start Axillary

Character 93b:
Marginal End Axillary



Character 94a:
Axillary Inguinal Contact

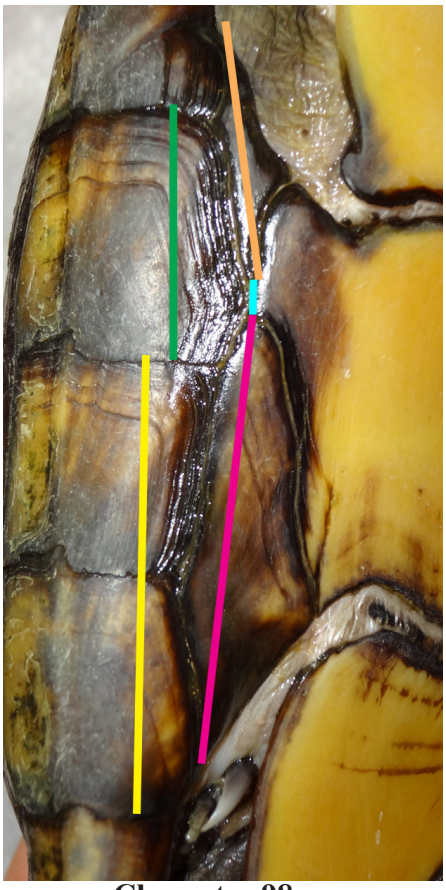
Character 94b:
Axillary-Inguinal Gap

Character 95a:
Marginal Start Inguinal

Character 95b:
Marginal End Inguinal

Character 96:
Length Inguinal vs Axillary Scute

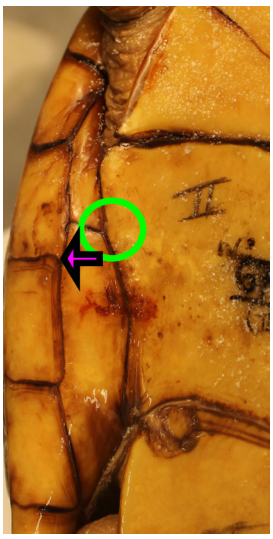
Character 97:
Length Axillary vs M5



Character 98a:
Length Inguinal vs M6/M7

Character 98b:
Length Interposterohumeral Sulcus vs M6/M7

Character 99:
Axillary-Inguinal Contact vs M5-M6 Sulcus



Character 96:
Length of Inguinal vs Axillary Scute.
This character describes the ratio of the length of the Inguinal scute (magenta line, measured straight at longest points) versus the length of the Axillary scute (peach line – measured straight at longest points). Here it is 1.5x. Light blue line shows gap between the scutes (see Character 94b).

Character 97:
Length of Axillary vs M5
This character describes the relative length of the Axillary scute (peach line – measured straight at longest points) vs the straight length of M5, anterior to posterior sulcus (dark green line). Here it is subequal.

Character 98a:
Length of Inguinal vs M6/M7
This character describes the relative length of the Inguinal scute (magenta line, measured straight at longest points) versus the length of the combined M6 and M7 lengths (yellow line, measured straight anterior to posterior, sulcus to sulcus). Here it is subequal.

Character 98b:
Length of Interposterohumeral Sulcus vs M6/M7
This character (below) describes the relative length of the Interposterohumeral Sulcus (dark blue line, measured straight anterior to posterior) versus the length of the combined M6 and M7 lengths (yellow line, measured straight anterior to posterior, sulcus to sulcus). Here it is longer.

Character 99:
Axillary-Inguinal Contact vs M5-M6 sulcus
This character describes the relative position of the point of contact (light green circle) between the axillary and inguinal scutes (when no gap is present) against the level of the M5-M6 sulcus (black outlined magenta arrow). Here the contact occurs strongly posterior of the M5-M6 shared sulcus.

Character 100a:
Plastral Midline vs Anterior Lobe Length
This character describes the factor of the straight anterior to posterior midline plastral length (blue line) versus that of the anterior-to-posterior straight midline length of the anterior plastral lobe (black line).

Character 100b:
Plastral Midline vs Fixed Length
This character describes the factor of the straight anterior to posterior midline plastral length (blue line) versus that of the anterior-to-posterior straight midline length of the fixed plastral portion (yellow line).

Character 100c:
Plastral Midline vs Posterior Lobe Length
This character describes the factor of the straight anterior to posterior midline plastral length (blue line) versus that of the anterior-to-posterior straight midline length of the posterior plastral lobe (red line).

Character 100d:
Plastral Midline vs Inframarginal Row Length
This character describes the factor of the straight anterior to posterior midline plastral length (blue line) versus that of the full inframarginal length (green line). The inframarginal row length is measured straight from the anteriormost point of the axillary scute to the posterior most point of the inguinal scute, regardless of presence or absence of gap between the two.

Character 101a:
Inframarginal Row Length vs Interposterohumeral Sulcus
This character describes the relative lengths of the full inframarginal length (green line) to that of the anterior-to-posterior straight midline length of the interposterohumeral sulcus (yellow) line. Here the value is 1.5x.

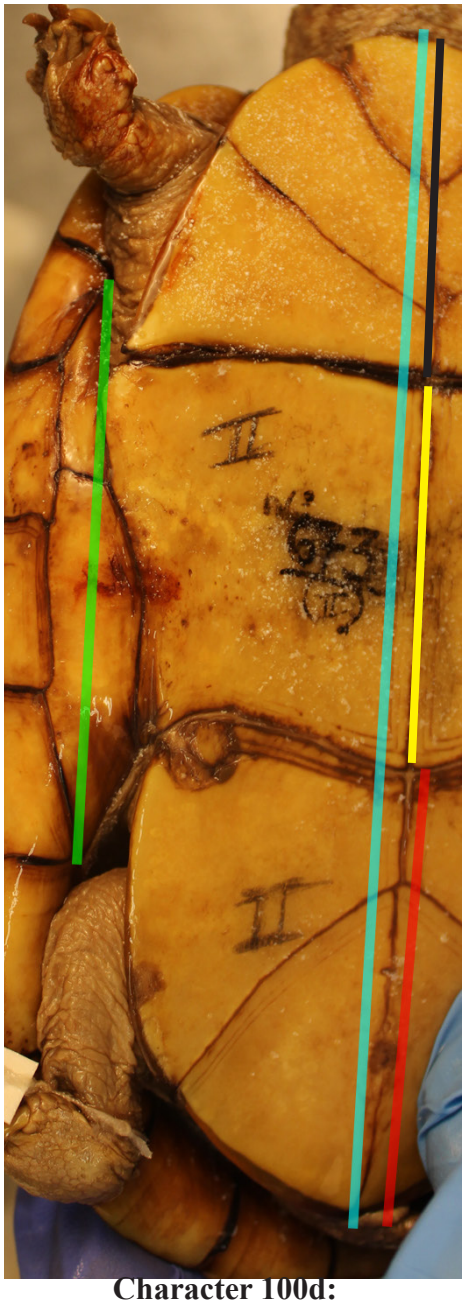
Character 101b:
Inframarginal Row Length vs Anterior Lobe
This character describes the relative lengths of the full inframarginal length (green line)to that of the anterior-to-posterior straight midline length of the anterior plastral lobe (black line).

Character 101c:
Inframarginal Row Length vs Posterior Lobe
This character describes the relative lengths of the full inframarginal length (green line)to that of the anterior-to-posterior straight midline length of the posterior plastral lobe (red line).

Character 100a:
Plastral Midline vs Anterior Lobe Length

Character 100b:
Plastral Midline vs Fixed Length

Character 100c:
Plastral Midline vs Posterior Lobe Length



Character 100d:
Plastral Midline vs Inframarginal Row Length

Character 101a:
Inframarginal Row Length vs Interposterohumeral Sulcus

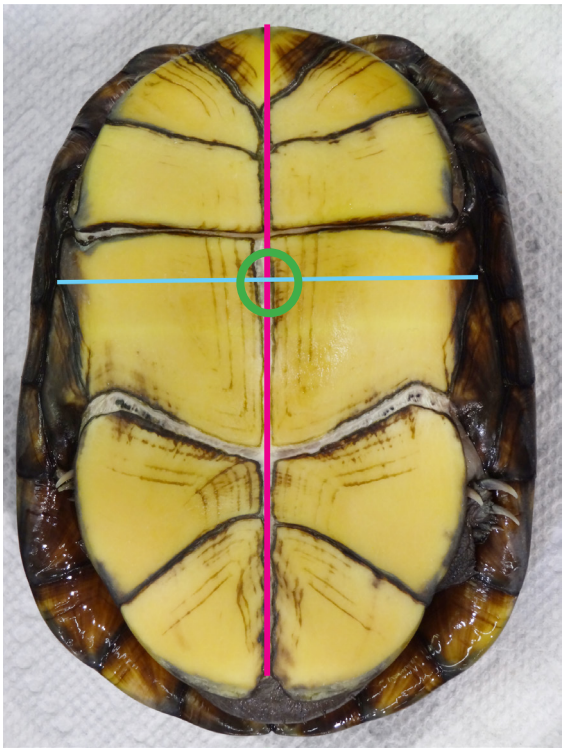
Character 101b:
Inframarginal Row Length vs Anterior Lobe

Character 101c:
Inframarginal Row Length vs Posterior Lobe

Character 102:
Plastral Intersection

This character describes the positional (intersectional) relationship of the occurrence (green circle) of the widest level of the fixed portion of the plastron (light blue line) relative to that of the anterior-to-posterior level of the plastral midline (magenta line). The widest point is typically measured at the point where the posterohumeral scute meets with the axillary/inguinal scute sulcus or meets the marginal scute sulcus. Here it occurs at the .39 point of the midline plastral length.

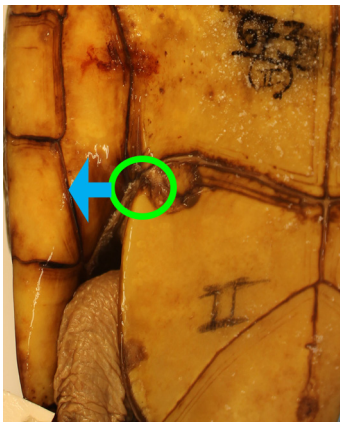
Character 102:
Plastral Intersection



Character 103:
Posterior Hinge vs Marginal 7

This character describes the relative position of the exteriormost point (green circle) of the posterior hinge to that level of M7 (blue arrow). Here it occurs at the M7 midpoint.

Character 103:
Posterior Hinge vs Marginal 7



Character 104:
Bridge Grooves

This character describes the presence of distinct anterior-to-posterior grooves (blue line and blue indicator arrow) on the fixed (middle) portion of the plastron (the posterohumeral scutes). The grooves are skeletal nature and typically run parallel to the midline; that is they underly the scutes and are inscribed into the bone of the hyo-hypoplastra. Grooves illustrated here on *K. scorpioides.*

Character 104:
Bridge Grooves

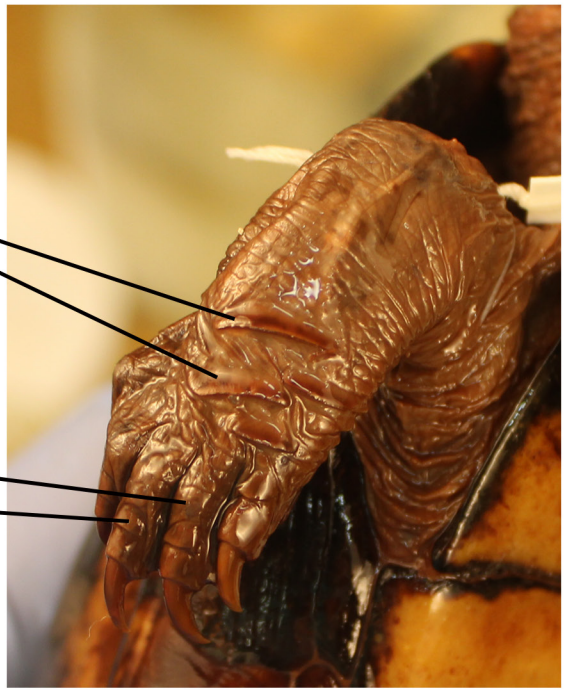
Characters 105 through 139

Morphology and metrics of the head and limbs; coloration and patterns of the species.

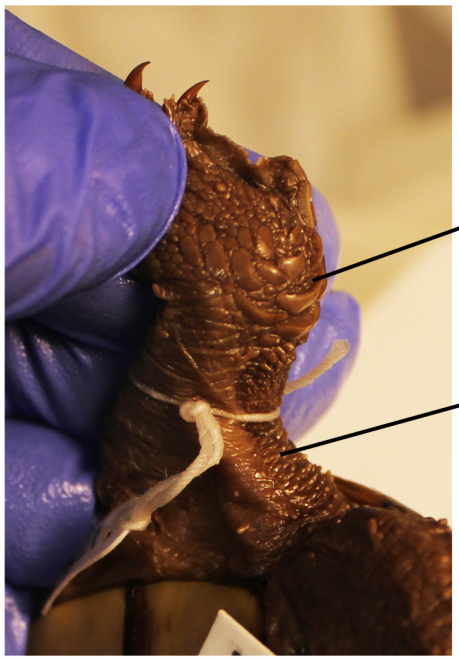
Figure 11. Male (left) and female *Kinosternon alamosae.*

Nomenclature of the Mud Turtle Limbs and Tail

Dorsal View, right forelimb

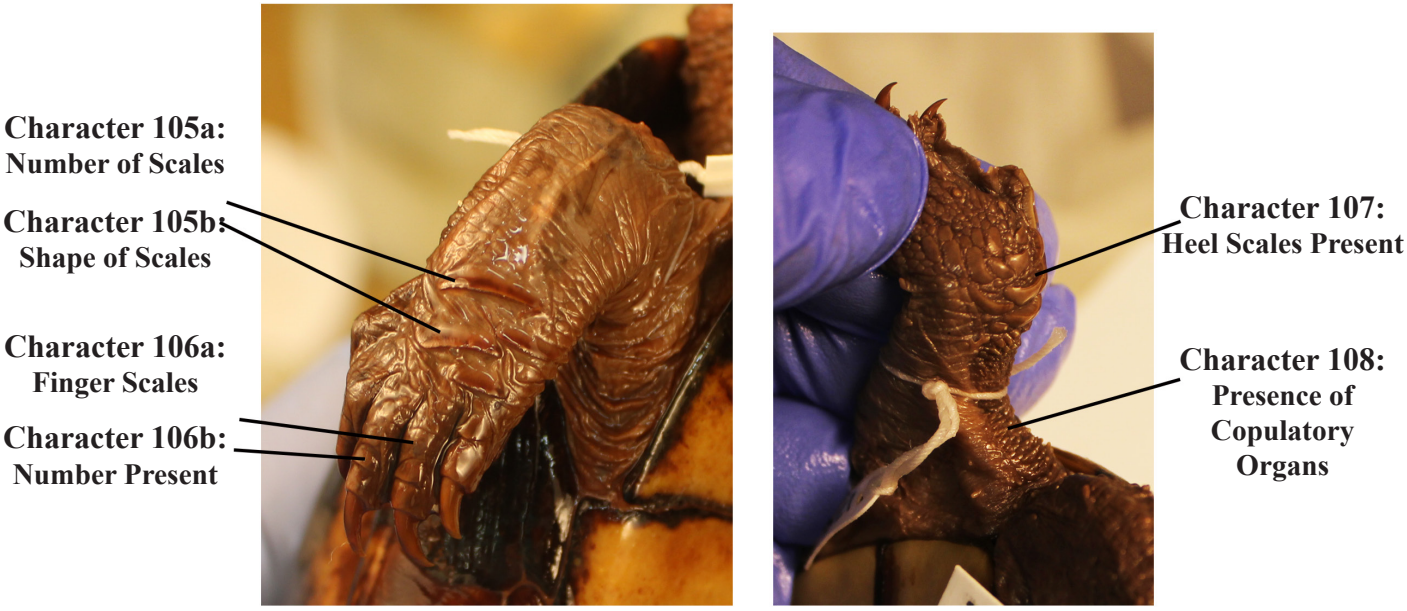


Ventral View, Left Hindlimb



Ventral view tail, male

Ventral view tail, female



Character 105a: Number of Scales
This character describes the number of scales present on the dorsal surface of the forelimb above the phalanges. Here four occur in this *Kinosternon hirtipes*.

Character 105b: Shape of Scales
This character describes the shape of the scales. Here they are transversely elongated.

Character 106a: Finger Scales
This character describes the presence of scales on the dorsal surface of the forelimb phalanges. Here they are present on all digits.

Character 106b: Number Present
This character describes the number of scales present on the dorsal surface of the forelimb phalanges. Here it is 2 on the 1st finger and 3 on all others.

Character 107: Heel Scales Present
This character describes the presence of scales on the heel of the hindlimb as seen in this *Kinosternon hirtipes*, often arranged as a rosette.

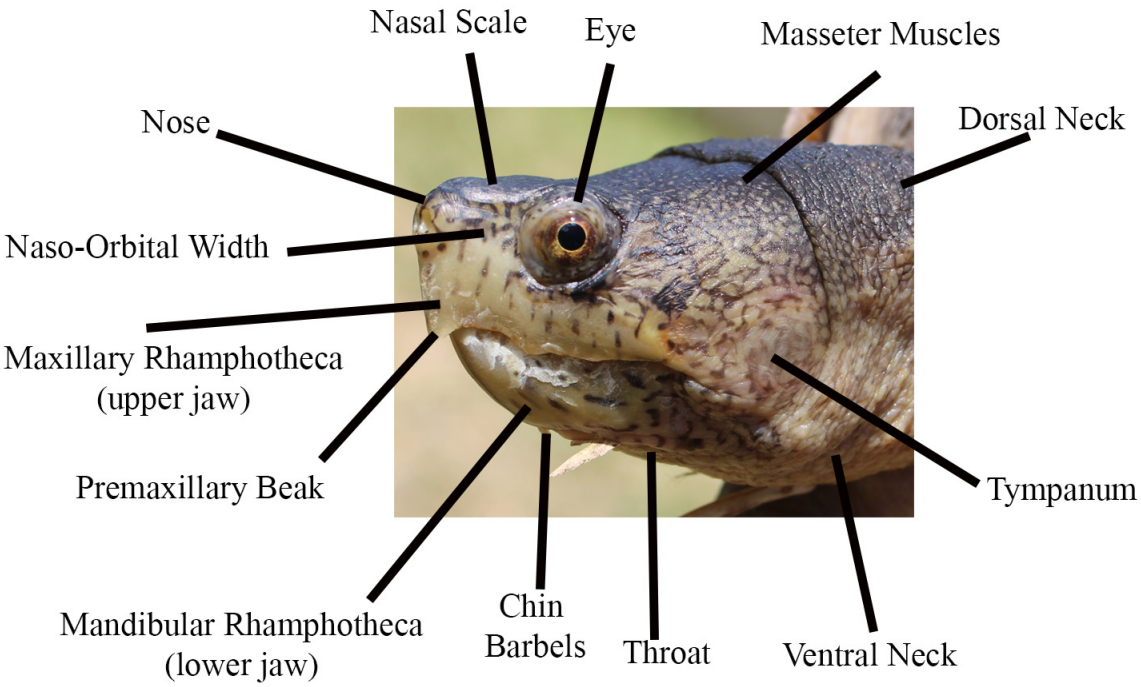
Character 108: Presence of Copulatory Organs
This character describes the presence or absence of copulatory (clasping) organs on the posterior thigh and crus of the hind limb in male specimens of the species, as in this *Kinosternon hirtipes*.

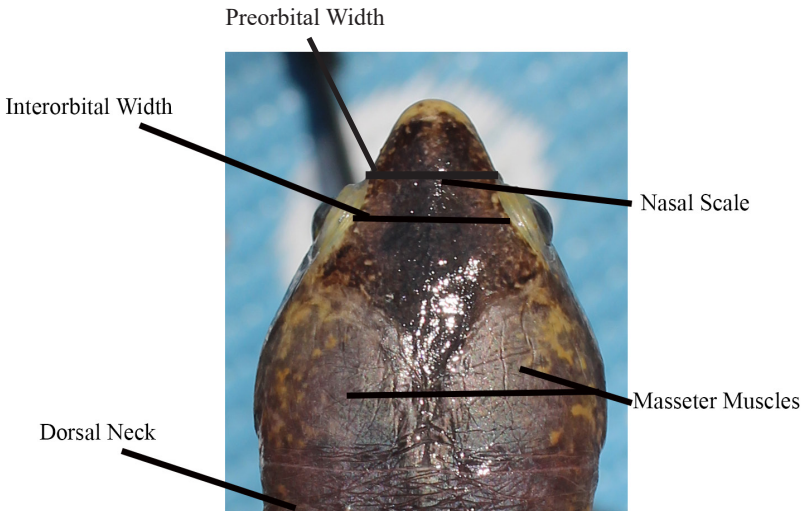
Character 109a: Terminal Spur Present
This character describes the presence of a keratinous terminal spur at the end of the tail, as in this male *Kinosternon hirtipes*.

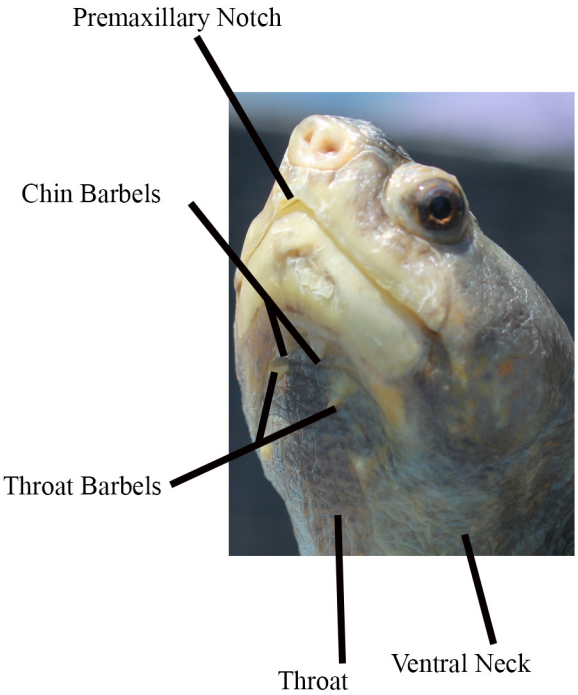
Character 109b: Terminal Spur in Both Sexes
This character describes the presence of a keratinous terminal spur at the end of the tail in both sexes, as in this female *Kinosternon hirtipes*.

Character 110: Tail Papillae
This character describes degree of papillae of the tail – heavily papillated in this *Kinosternon hirtipes* but moderate in this *Kinosternon angustipons* (lower left) and sparse in this *Kinosternon herrerai* (lower right).

Nomenclature of the Mud Turtle Head

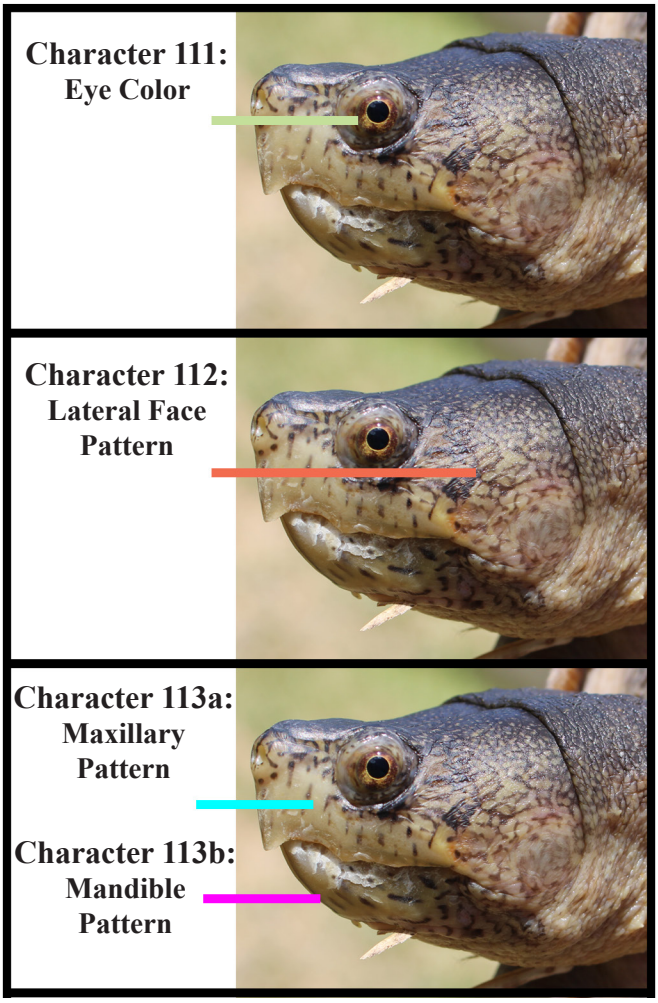






Character 111: Eye Color
This character describes the color and pattern (indicated by green line) of the sclera, iris and iris ring of the eye. MOdlled species is *Kinosternon steindachneri*, male.

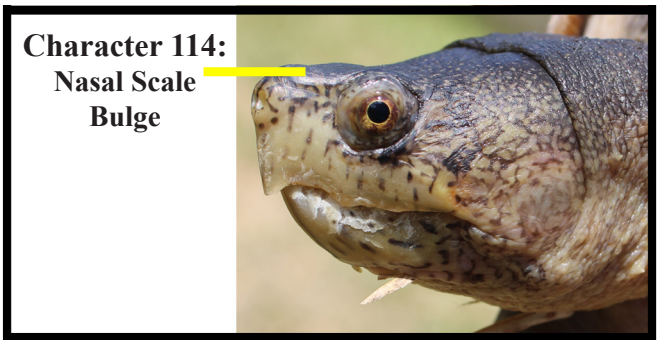
Character 112: Lateral Face Pattern
This character describes the color and pattern (indicated by orange line) of the lateral sides of the head and face, including the tympanum.



Character 113a: Maxillary Pattern
This character describes the color and pattern (indicated by light blue line) of the maxillary rhamphotheca.

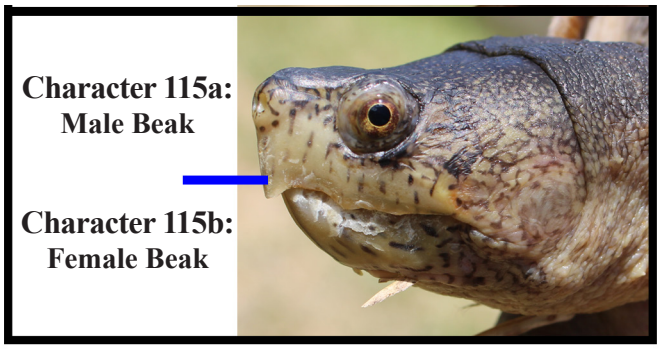
Character 113b: Mandible Pattern
This character describes the color and pattern (indicated by magenta line), of the mandibular rhamphotheca.

Character 114: Nasal Scale Bulge
This character describes the relative elevation (indicated by yellow line) of the nasal scale. Here it is relatively flat.



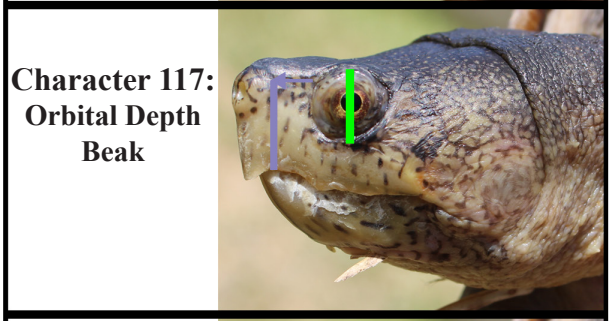
Character 115a: Male Beak
This character describes the presence and degree of a sharp hook (dark blue line) in the beak of the maxilla. Here it is moderate in this male *K. steindachneri*.

Character 115b: Female Beak
This character describes the presence and degree (or absnece) of a beak in the female of the species.

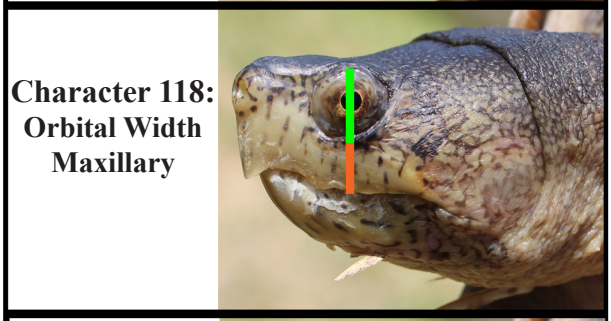


Character 116: Orbital-Rostral Width
This character describes the relative width of the orbit of the eye (measured straight anterior to posterior, light blue line) to the width of the lateral rostral region (orange line, measured straight anterior to posterior, from exterior most point of nose to start of orbit). Here it is shorter.

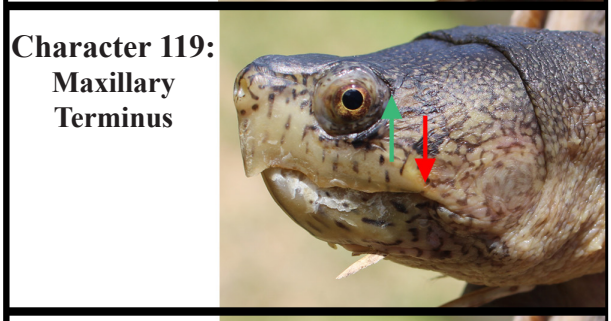
Character 117: Orbital Width Beak
This character describes the maximum depth (height) of the orbit (green line) versus the depth of the beak between the nose and orbit (purple line). The latter is measured from the dorsal most point of the maxilla direct to the ventral point on the nasal scale. Here it is of lesser value.



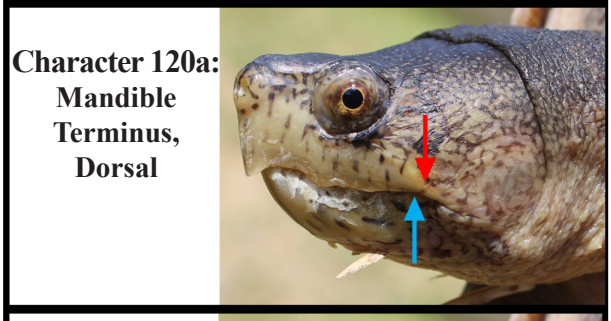
Character 118: Orbital Depth Maxillary
This character describes the maximum depth (height) of the orbit (green line) versus the depth of the maxillary rhamphotheca directly ventral between the ventral orbit and the maxilla edge (aka tomium, orange line). Here it is greater.



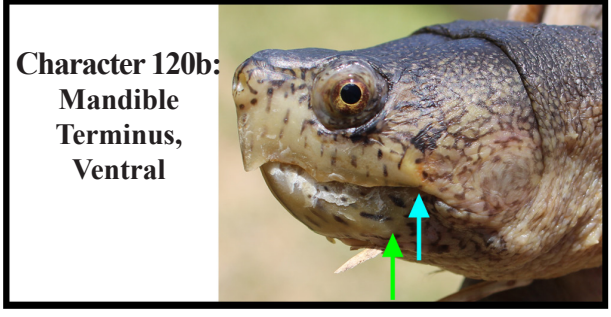
Character 119: Maxillary Terminus
This character describes the positional relationship between the terminus of the maxilla (posterior most point, red arrow, lateral view) to that of the posteriormost point of the orbit (green arrow). Here it is posterior.

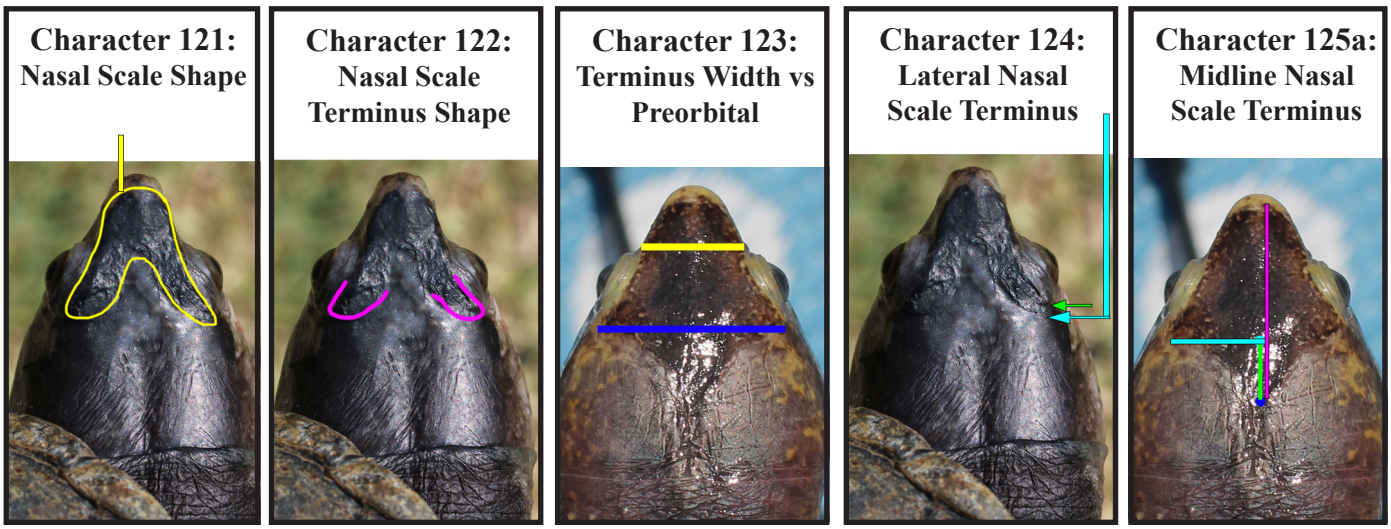


Character 120a: Mandible Terminus, Dorsal
This character describes the positional relationship between the terminus of the maxilla (posterior most point, red arrow, lateral view) to that of the posteriormost point of the dorsal mandible rhamphotheca (blue arrow). Here it is posterior.



Character 120b: Mandible Terminus, Ventral
This character describes the positional relationship (lateral view) between the terminus of the posteriormost point of the dorsal mandible rhamphotheca (blue arrow) to that of the posteriormost point of the ventral mandible (green arrow). Here it is posterior.





Character 121: Nasal Scale Shape
This character describes the overall shape (yellow outline) of the nasal scale in dorsal view. Here it is furcate with moderate thickness.

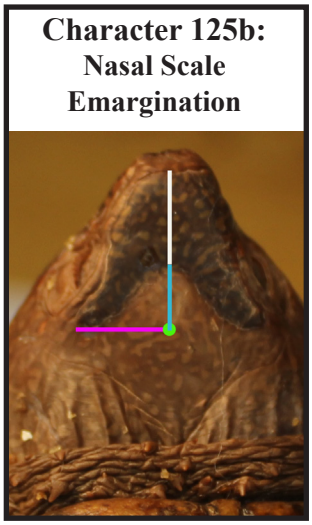
Character 122: Nasal Scale Terminus Shape
This character describes the overall shape (magenta outline) of the lateral terminus of the nasal scale in dorsal view. Here it is 'U-shaped' with moderate thickness.

Character 123: Terminus Width vs Preorbital
This character describes the factor of the width of the nasal scale at the greatest point of the termini (blue line, measured straight) versus that of the width of the preorbital (yellow line, measured straight at the points directly anterior of the orbits in dorsal view.

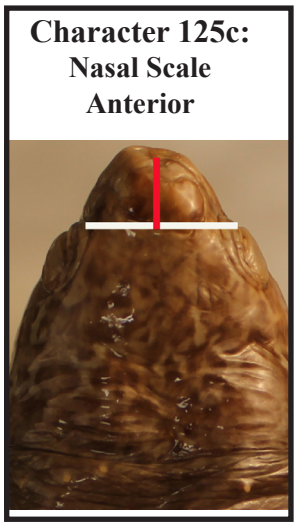
Character 124: Lateral Nasal Scale Terminus
This character describes the positional relationship of the lateral terminus of the nasal scale (large blue arrow) to the posteriormost point of the orbit (small green arrow) in dorsal view. Here it extends slightly posteriorly.

Character 125a: Midline Nasal Scale Terminus
This character describes the ratio of the anterior to posterior length of the nasal scale (magenta line to dark blue dot) to that portion of the nasal scale (green line) that occurs from the level of the terminus of the lateral nasal scale (light blue line, light blue dot) to the midline terminus of the nasal scale (dark blue dot). Here it is 3.5x.

Character 125b:
Nasal Scale Emargination
This character describes the midline length of the posterior emargination (light blue line, when present) of the nasal scale as a ratio of the dorsal head measured from the midline of the anteriormost portion of the nasal scale to the level of the terminus of the lateral nasal scale (white plus blue line) to the midline level of the terminus of the nasal scale (magenta line with green dot). Here it is .44 in this *K. hirtipes*.

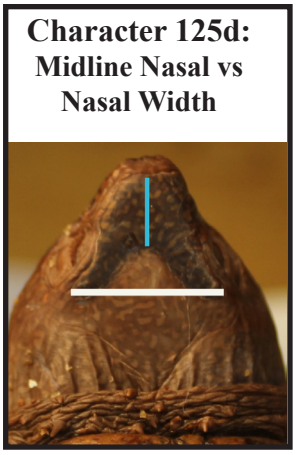


Character 125c:
Nasal Scale Anterior
This character describes the portion of the nasal scale (red line) that lies anterior of the anteriormost point of the interorbits (white line), as a ratio of the overall midline length of the nasal scale (red line). Here the value is 1 as the entirety of the nasal scale lies anterior of the orbits in this Aguascalientes kinosternid.



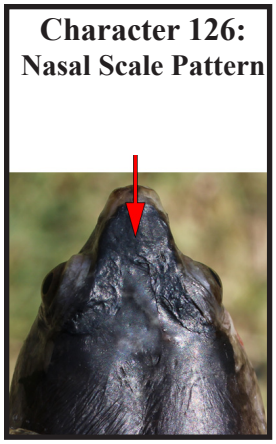
Character 125d:
Midline Nasal vs Nasal Width

This character describes the ratio of the midline portion of the nasal scale (blue line) versus the width of the nasal scale measured at its widest point (white line). Here it is .47x.



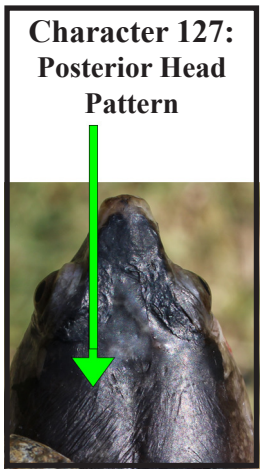
Character 126:
Nasal Scale Pattern

This character describes the color and pattern (red arrow) of the nasal scale.



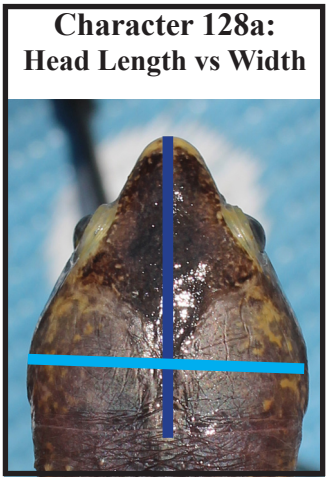
Character 127:
Posterior Head Pattern

This character describes the color and pattern of the posterior portion of the head (green arrow).



Character 128a:
Head Length vs Width

This character (right) describes the length of the head (dark blue line, measured midline from anterior moist point to back of cranium) to the width of the head (light blue line, measured perpendicular to the midline of the head at its maximum width).

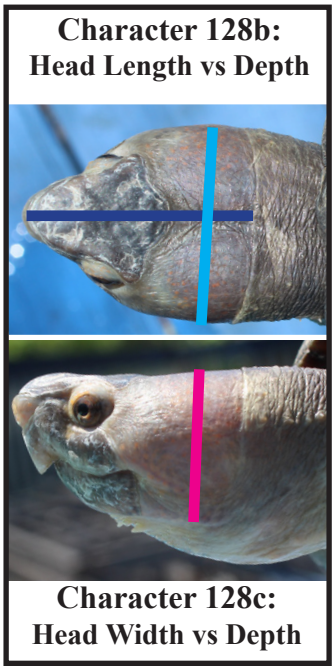


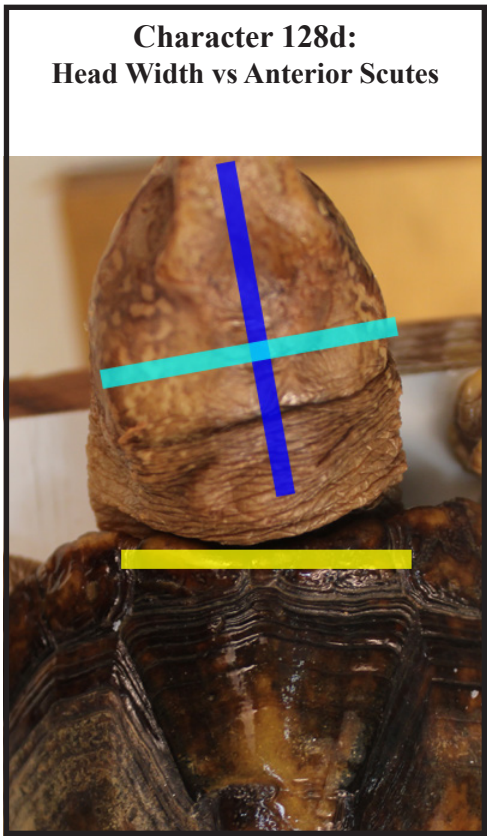
Character 128b:
Head Length vs Depth

This character (right) describes the length of the head (dark blue line, measured midline from anterior moist point to back of cranium) to the depth of the head (magenta line, measured dorso-ventrally, at the same point of greatest head width).

Character 128c:
Head Width vs Depth

This character (right) describes the width of the head (light blue line, measured perpendicular to the midline of the head at its maximum width) to the depth of the head (magenta line, measured dorso-ventrally, at the same point of greatest head width).





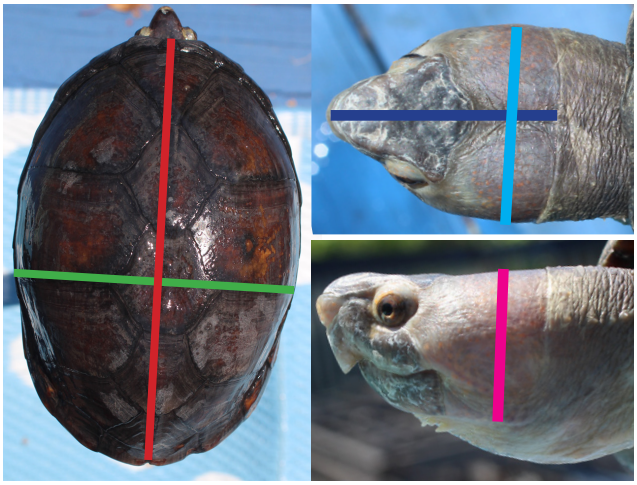
Character 128d: Head Width vs Anterior Scutes

This character (right) describes the width of the head (light blue line, measured perpendicular to the midline of the head, dark blue line) at its maximum width to the width of the anterior carapace across the 1st marginals (yellow line, midpoints of M1-M2 sulcus). In this *K. scorpioides* complex specimen head width equals or exceeds the anterior carapace.

Character 129a:
Carapace Length vs Head Length

Character 129b:
Carapace Length vs Head Width

Character 129c:
Carapace Length vs Head Depth



Character 130a:
Carapace Width vs Head Length

Character 130b:
Carapace Width vs Head Width

Character 130c:
Carapace Width vs Head Depth

Character 129a: Carapace Length vs Head Length
This character records the ratio of the Carapace Length (red line, measured staight anterior to posterior down midline) to that of the head length (dark blue line, measured midline from anterior most point to back of cranium).

Character 129b: Carapace Length vs Head Width
This character records the ratio of the Carapace Length (red line, measured staight anterior to posterior down midline) to the width of the head (light blue line, measured perpendicular to the midline of the head at its maximum width).

Character 129c: Carapace Length vs Head Depth
This character records the ratio of the Carapace Length (red line, measured staight anterior to posterior down midline) to the depth of the head (magenta line, measured dorso-ventrally, at the same point of greatest head width).

Character 130a: Carapace Width vs Head Length
This character records the ratio of the Carapace Width (green line, measured staight perpendicular to the midline at the point of greatest carapace width) down midline to that of the head length (dark blue line, measured midline from anterior most point to back of cranium).

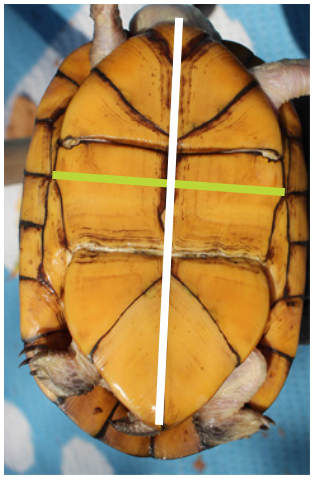
Character 130b: Carapace Width vs Head Width
This character records the ratio of the Carapace Width (green line, measured staight perpendicular to the midline at the point of greatest carapace width) to the width of the head (light blue line, measured perpendicular to the midline of the head at its maximum width).

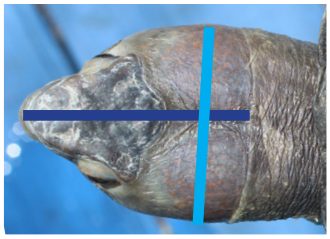
Character 130c: Carapace Width vs Head Depth
This character records the ratio of the Carapace Width (green line, measured staight perpendicular to the midline at the point of greatest carapace width) to the depth of the head (magenta line, measured dorso-ventrally, at the same point of greatest head width).

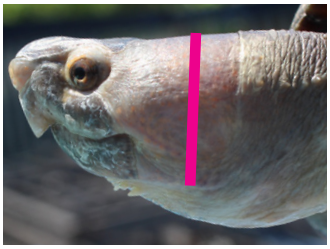
Character 131a:
Plastron Length vs Head Length

Character 131b:
Plastron Length vs Head Width

Character 131c:
Plastron Length vs Head Depth







Character 132a:
Plastron Width vs Head Length

Character 132b:
Plastron Width vs Head Width

Character 132c:
Plastron Width vs Head Depth

Character 131a: Plastron Length vs Head Length
This character records the ratio of the Plastron Length (white line, measured staight anterior to posterior down midline) to that of the head length (dark blue line, measured midline from anterior most point to back of cranium).

Character 131b: Plastron Length vs Head Width
This character records the ratio of the Plastron Length (white line, measured staight anterior to posterior down midline) to the width of the head (light blue line, measured perpendicular to the midline of the head at its maximum width).

Character 131c: Plastron Length vs Head Depth
This character records the ratio of the Plastron Length (white line, measured staight anterior to posterior down midline) to the depth of the head (magenta line, measured dorso-ventrally, at the same point of greatest head width).

Character 132a: Plastron Width vs Head Length
This character records the ratio of the Plastron Width (lime green line, measured staight perpendicular to the midline at the point of greatest plastron width) down midline to that of the head length (dark blue line, measured midline from anterior most point to back of cranium).

Character 132b: Plastron Width vs Head Width
This character records the ratio of the Plastron Width (lime green line, measured staight perpendicular to the midline at the point of greatest plastron width) to the width of the head (light blue line, measured perpendicular to the midline of the head at its maximum width).

Character 132c: Plastron Width vs Head Depth
This character records the ratio of the Plastron Width (lime green line, measured staight perpendicular to the midline at the point of greatest plastron width) to the depth of the head (magenta line, measured dorso-ventrally, at the same point of greatest head width).

Character 133: Carapace Coloration
This character (black line) describes the overall base color of the carapace and any noteworthy pattern.

Character 134a: Plastron Coloration
This character (light blue line) describes the overall base coloration of the plastron.

Character 134b: Plastral Pattern
This character (dark blue line) describes any prominent pattern on the plastron such as dark streaking and sulci.

Character 134c: Coloration Ventral Marginals
This character (magenta line) describes the colortion of the ventral surface of the marginals.

Character 134d: Color Axillary Scute
This character (green line) describes the coloration of the axillary scute.

Character 134e: Color Inguinal Scute
This character (yellow line) describes the coloration of the inguinal scute.

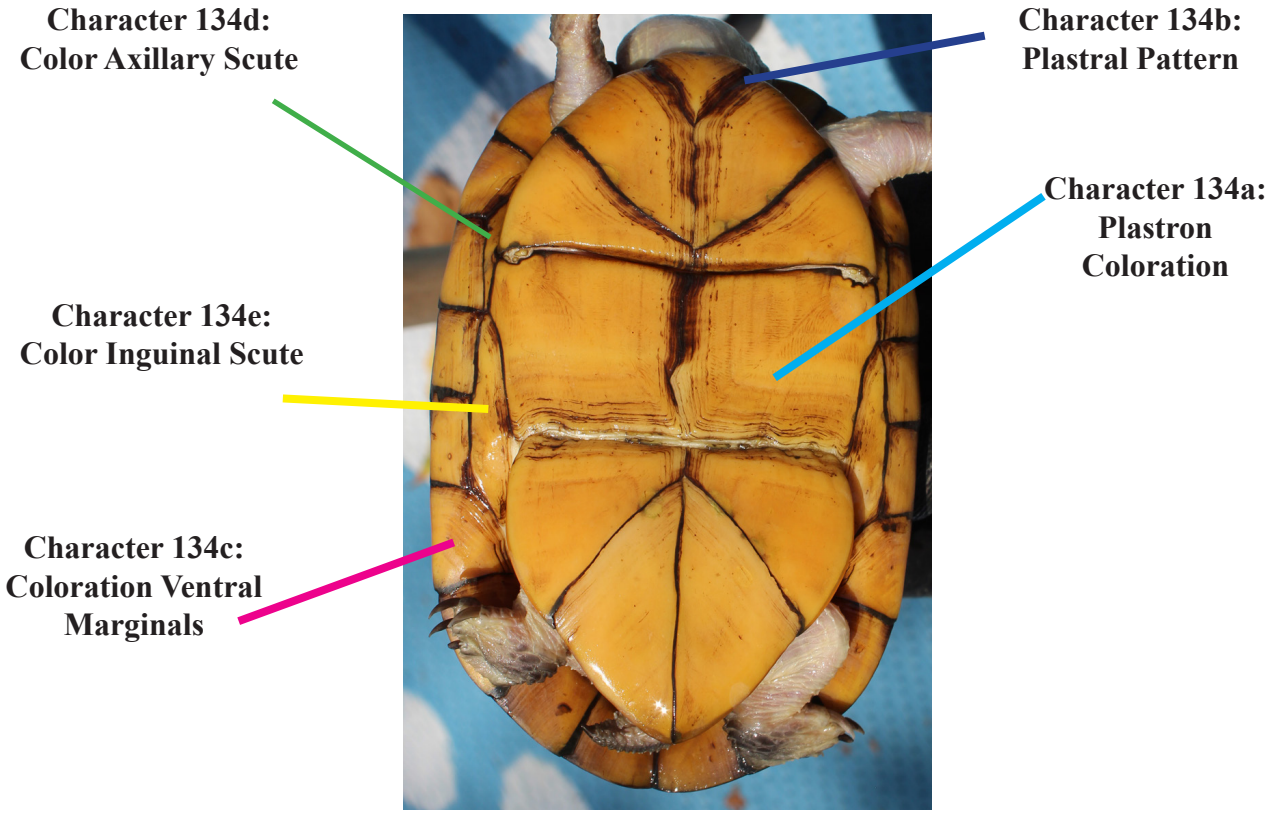
Character 135a: Throat Color
This character (pink line) describes the coloration and pattern of the throat.

Character 135b: Dorsal Neck Color
This character (forest green line) describes the coloration of the dorsal surface of the neck.

Character 135c: Ventral Neck Color
This character (pastel green line) describes the coloration of the ventral surface of the neck.

Character 136a: Dorsal Forelimb Color
This character (lime green line) describes the coloration of the dorsal surface of the forelimb.

Character 136b: Ventral Forelimb Color
This character (red line) describes the coloration of the ventral surface of the forelimb.

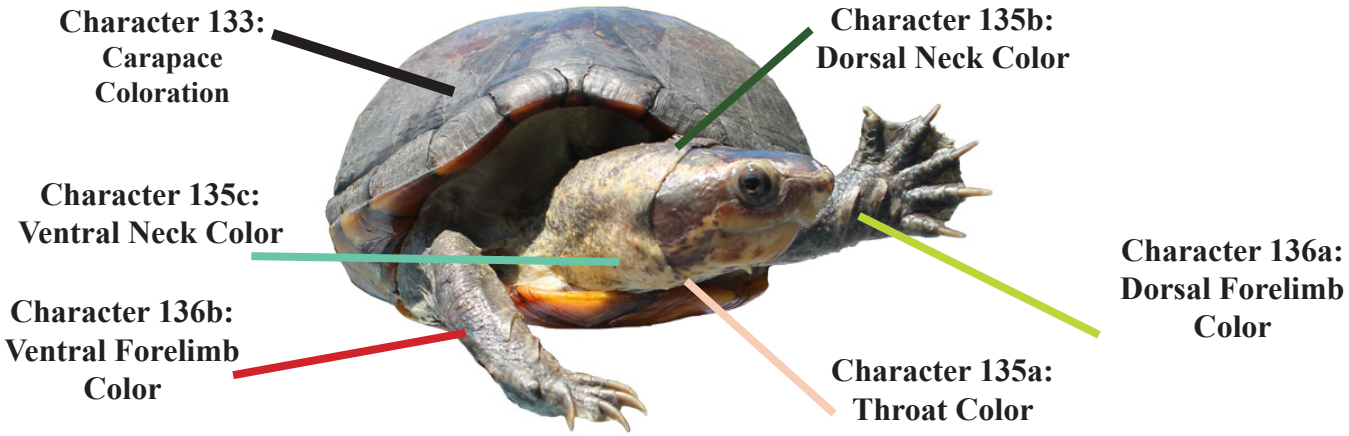


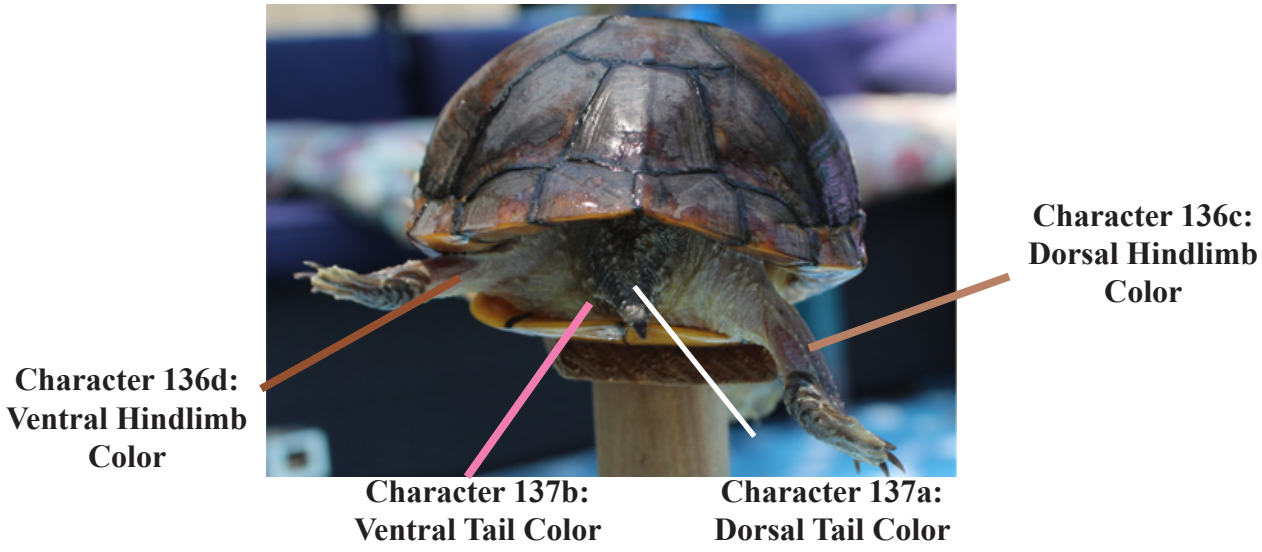
Character 136c: Dorsal Hindlimb Color
This character (light brown line) describes the coloration of the dorsal surface of the hindlimb.

Character 136d: Ventral Hindlimb Color
This character (dark brown line) describes the coloration of the ventral surface of the hindlimb.

Character 137a: Dorsal Tail Color
This character (white line) describes the coloration of the dorsal surface of the tail.

Character 137b: Ventral Tail Color
This character (lavender line) describes the coloration of the ventral surface of the tail.

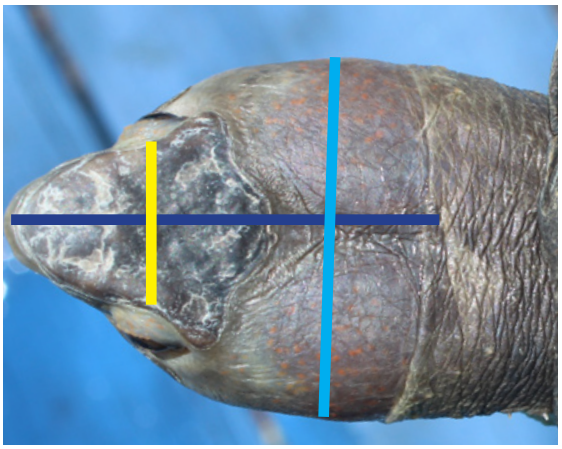


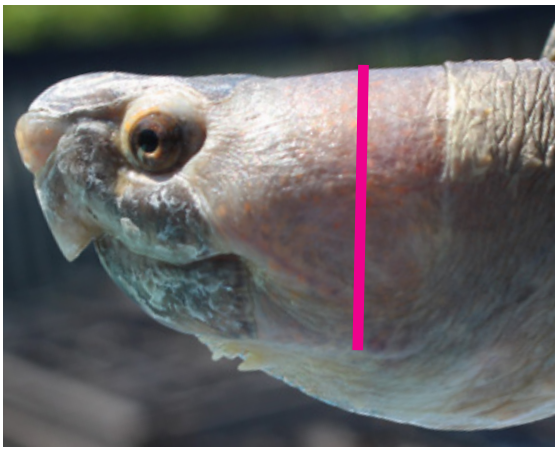


Character 138a:
Head Length vs Interorbital Width

Character 138b:
Head Width vs Interorbital Width

Character 138c:
Head Depth vs Interorbital Width





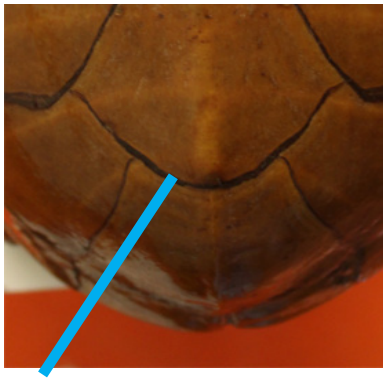
Character 138a:
Head Length vs Interorbital Width
This character (above) describes the length of the head (dark blue line, measured midline from anterior moist point to back of cranium) to the interorbital width (yellow line, measured straight on top of the head perpendicular to the midline at the midpoints of the orbits).

Character 138b:
Head Width vs Interorbital Width
This character (above) describes the width of the head (light blue line, measured perpendicular to the midline of the head at its maximum width) to the interorbital width (yellow line, measured straight on top of the head perpendicular to the midline at the midpoints of the orbits).

Character 138c:
Head Depth vs Interorbital Width
This character (right) describes the depth of the head (magenta line, measured dorso-ventrally, at the same point of greatest head width). to the interorbital width (yellow line, measured straight on top of the head perpendicular to the midline at the midpoints of the orbits).

Character 139:
Autapomorphy/ Unique Character
This character observes a character or set of characters unique to a specific species (autapomorphy) or unique to a limited group of species. In this example, the broadly wide, deep U-shape of the V4-V5 sulcus (light blue line) in this *K. herrerai* is a unique character.

Character 139:
Autapomorphy/ Unique Character



Character 140:
Chin & Throat Barbels

Character 140:
Chin & Throat Barbels

This final character observes the size, number and location of the barbels on the underside of the chin (posterior to the mandibular rhamphotheca) and on the throat itself, as seen in the assorted taxa in the *Kinosternon integrum* species complex.