Defining Turtle Diversity: Proceedings of a Workshop on Genetics, Ethics, and Taxonomy of Freshwater Turtles and Tortoises
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Responsible Vouchering in Turtle Research: An Introduction and Recommendations

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Abstract. – Voucher specimens are critical to the advancement of research efforts on turtles, and by association, for conservation efforts associated with this group. This paper addresses the importance of voucher specimens and provides recommendations for responsible practices associated with voucher specimens. For the purposes of this paper, a voucher specimen is defined as a biological specimen, the primary function of which is to provide verification for the taxonomic identification assigned to an animal and any eventual published or reported scientific investigations associated with it. A traditional voucher specimen for a turtle consists of a fluid-preserved specimen or a complete skeleton and its associated data appropriately preserved for permanent storage and housed in a curated collection for posterity. Although not optimal, a non-traditional voucher may also provide verification for taxonomic identification and may include image or acoustic data, eggs or eggshells, or tissue samples. Examples are given of when a traditional voucher specimen deposited in a curated collection is recommended and when alternatives to the traditional voucher specimen, such as an *e*-voucher, may be used. In addition, a worldwide survey of curated collections holding turtles was conducted and the percentage of turtles represented in reptile collections is reported.

Key Words. – Reptilia; Testudines; turtles; traditional voucher specimen; non-traditional voucher specimen; *e*-voucher; curated collection; tissue sample

Turtles[1] (Order Testudines) comprise just 3.7% of all named extant reptile species (307 turtle species out of 8240 total named reptiles; Uetz and Hallermann, 2007). Extant turtles are a highly distinctive group characterized by several features, including a secondarily anapsid skull, a shell that encloses both limb girdles, an external ear supported by a large, semicircular quadrate, and toothless jaws (Ernst and Barbour, 1989; Meylan, 2001). Approximately 40% of all extant turtle species are considered threatened and listed as either Critically Endangered, Endangered, or Vulnerable by the IUCN - World Conservation Union (Khamsi, 2004; IUCN, 2007). Key threats to turtles include direct mortality by collection for food, traditional medicine, and the pet trade, in addition to incidental mortality caused by road kills, habitat loss, and the introduction of predators and competitors (van Dijk et al., 2000; Khamsi, 2004).

Species boundaries play a crucial role in the prioritization of conservation efforts for turtle taxa (Avise, 1989; Remsen, 1995; Reynolds et al., 1996; Sites and Crandall, 1997; Soltis and Gitzendanner, 1999; DeSalle and Amato, 2004). Taxonomists use many different characters, including morphological and/or molecular, in the delineation of species and/or subspecies (Wiley, 1978; Frost and Hillis, 1990; de Queiroz, 1998, 1999). Over time, species concepts, criteria, and the characters used to distinguish species may change. It is therefore not uncommon that a species description may be reviewed and challenged over the years (e.g., Parham et al. 2001). Type specimens for new species and voucher specimens from published studies provide researchers with the option to use alternative methods or advancing technologies to re-examine previous descriptions or conclusions. Voucher specimens also allow independent verification of the taxonomic identification of individuals used to test the hypotheses generated in the study (Reynolds et al., 1996). It is for these reasons that voucher specimens are critical to the advancement of research efforts on turtles, and by association, for conservation efforts associated with this group.

This paper will address the importance of voucher specimens and provide recommendations for responsible practices associated with voucher specimens.

The Definition of a Voucher Specimen

A voucher specimen has previously been defined in the literature by authors representing various biological disciplines:

[1] For the purposes of this paper, a turtle refers to all species included in the Order Testudines, including turtles, tortoises, and terrapins.

Lee et al. (1982) stated that for a general biological voucher, "*A voucher specimen is one which physically and permanently documents data in an archival report by: 1). verifying the identity of the organisms(s) used in the study; and, 2). by so doing, ensures that a study which otherwise could not be repeated can be accurately reviewed or reassessed*."

Yates (1985) defined a mammalian voucher specimen as one "*which serves to physically and permanently document data in an archival report by 1) verifying the identify of the organisms(s) used in the study and 2) by so doing, assuring the repeatability of the study which otherwise could not be repeated and/or accurately reviewed or reassessed. Thus, voucher specimens are the sole means to verify the data documented in a report and to make historical comparison possible*."

Reynolds et al. (1994) in referring to amphibians defined voucher specimens as "*Specimens that permanently document data in an archival report*" and described the role of vouchers, including to "*provide a basis for verification of identifications and thereby duplication of a study*."

Reynolds et al. (1996) in discussing mammals defined voucher specimens as "*Specimens that permanently document data in an archival report. Such specimens and corresponding data assembled during field studies of mammals, particularly the small and medium-size species that are difficult to identify and often poorly known, are critical for accurate identification of the animals studied and for verification of the data gathered and reported as resulting from the investigation*."

Winker et al. (1996) stated with regard to voucher specimens of birds that "*The study skin is the basis for identification in birds – not tissue specimens. When tissues are collected, good scientific procedure requires that a voucher specimen (i.e. a specimen that enables the identification of accompanying material) be preserved and deposited in a research collection. Voucher specimens serve as quality control for phylogenetic and population genetic analyses based on tissues."*

Huber (1998) defined voucher specimens of invertebrates in the broad sense as "*..all biological specimens having the minimum information of collection locality (ideally specified by latitude, longitude, altitude) and date that are preserved to document biological research, including taxonomic research*."

Barkworth and Jacobs (2001) defined plant voucher specimens as "*…specimens that are made from the biological entities used in a research project and deposited in a recognized, active herbarium or museum."*

GenBank® (http://www.ncbi.nlm.nih.gov/projects/collab/FT/index.html; for the submission of sequence data) defines a specimen voucher as *"an identifier of the individual or collection of the source organism and the place where it is currently stored, usually an institution*."

For the purposes of this paper, a voucher specimen is defined as: *a biological specimen - the primary function of which is to provide verification for the taxonomic identification assigned to an animal and any eventual published or reported scientific investigations associated with it. A traditional voucher specimen for a turtle consists of a fluid-preserved specimen or a complete skeleton and its associated data appropriately preserved for permanent storage and housed in a curated collection for posterity. Although not optimal, a non-traditional voucher may also provide verification for taxonomic identification and may include image or acoustic data, eggs or eggshells, or tissue samples*. Practical guidelines for the preservation of traditional voucher specimens for reptiles and amphibians may be found elsewhere (e.g., Simmons, 2002, and references therein).

"Curated collections" refer to natural history museums or other institutions with demonstrated long-term commitments to biological collections, including adequate staffing, protection from physical hazards, appropriate storage for specimens and samples, accessibility to the specimens by the research community, compliance with national and other regulations, and written policies for collection management (Lee et al., 1982). The practice of holding specimens in private and/or stand-alone collections or on solely web-based and/or temporary databases is strongly discouraged. Collections such as these are short-lived and are typically dependent on one individual's commitment, not an institution's, and therefore the prospects for long term preservation of specimens is not secure (Corthals and DeSalle, 2005; Hanner et al., 2005). Lists of curated collections may be found in Dessauer and Hafner (1984), Leviton et al. (1985, 1988), Prendini et al. (2002), and Corthals and DeSalle (2005).

The minimum required information for a specimen accessioned and catalogued into a curated collection includes: a unique sample designation, date and time of collection, sex, name of collector, taxonomic identification and standard measurements, in addition to any other relevant information regarding the collection of that specimen (Lee et al., 1982; Reynolds et al., 1996).

A voucher specimen should accompany any study when the scientific name assigned to individuals is significant to the content or results of the paper (Reynolds et al., 1996; Barkworth and Jacobs 2001). A published scientific study which lists all "specimens examined" within the publication provides that study with the potential for repeatability, a basic tenet of scientific practice (Ruedas et al., 2000). Ideally, within the publication the authors should list the collection where the specimen is stored and its catalog number, in addition to the locality information, date of collection, and name of collector (Prendini et al., 2002).

A search of nucleotide submissions to GenBank® on the National Center for Biotechnology Information's website (http://www.ncbi.nlm.nih.gov/) highlights some of the issues related to vouchers and their importance with regard to turtles. Our core nucleotide search for Testudines, conducted on 15 October 2007, found that 1311 sequences out of a total of 6751 (approximately 19%) provided voucher specimen information. Over one-half of these submissions were associated with one author (768/1311). Approximately

one-half of these submissions were tissue samples (620/1311) and a great majority of these samples (616/620) were associated with one author. One-third of these submissions (436/1311) were deposited during the first ten months of 2007 and no voucher specimens were associated with sequences submitted to GenBank® prior to 2001.

An example highlighting the importance of voucher specimens and of providing the resources necessary for the repetition of a study was found in a review of the aforementioned 6751 sequences. In Cervelli et al. (2003), sequence data was submitted to GenBank® for 16 chelonian species, however it was found that one of the sequence accession numbers, that listed for *Cyclemys dentata* (AJ310188), was actually the sequence for *Oncorhynchus mykiss*, a rainbow trout. We were unable to locate any sequence data in GenBank® for *Cyclemys dentata* associated with this manuscript (Cervelli et al., 2003). By providing information relating to voucher specimens in the publication, ideally for both traditional specimens and for tissue samples, Cervelli et al. (2003) would have provided subsequent researchers the ability to verify the data presented in their paper.

There are several possible reasons for reluctance by researchers to collect and preserve turtles as a traditional voucher specimen, including: 1) because turtles are long-lived (Gibbons, 1987); 2) copious amounts of formalin are required to preserve a large specimen (Forstner et al., 1997); 3) it may be difficult to find museum collections with adequate storage space, especially for large specimens (Gans, 1989); 4) concerns that sacrificing animals impacts populations (Shine, 1996; Stuebing, 1998; Patterson, 2002), and lastly, 5) there may be an unwillingness to sacrifice animals held as pets. These concerns should be carefully weighed against the increased value of the data associated with the specimen and the potential for future research as well the overall importance of museum collections in general to research and conservation efforts for all taxa (Remsen 1995; Earl of Cranbrook 1997; Shaffer et al., 1998; Suarez and Tsutsui, 2004).

Turtle Specimens in Natural History Museums Worldwide

We conducted a survey via email between September – December 2005 of selected museums in Africa, Asia, Europe, and North America, with known herpetological contents, regarding their reptile and turtle holdings. Responses were received from 63 institutions and are compiled in Appendix I. Data quality (accurate specimen counts for total reptiles and total turtles and a low backlog of unregistered material) was best for North American museums; elsewhere, accurate counts were received only from a few of the major museums. Most respondents from museums in Europe and Asia mentioned that no electronic database existed for their collections. Several could supply only a single catalogue number for a series of specimens or jars containing several specimens (these have not been listed), and two collections mentioned that a significant amount of additional material had not yet been catalogued. The percentage of turtles represented in reptile collections ranged from 0% up to 32%, with an average of 5% representation (Appendix I).

One major systematic collection for turtles, the Chelonian Research Institute, Oviedo, Florida has nearly 11,150 catalogued and 300 non-catalogued specimens of turtles (P.C.H. Pritchard, *pers. comm.*). On the other side of the spectrum, a few collections reported a few or even no turtle specimens in their collection. Wildlife Heritage Trust of Sri Lanka, the largest systematic collection in Sri Lanka, reported no turtles, and attributed this to the fact that none of the staff have worked on the group (R. Pethiyagoda, *pers. comm.*). Low figures were also found in regional collections located in areas with relatively depauperate or poorly studied turtle faunas (e.g., Pakistan, the Philippines, Israel, and Iran).

While the size of a collection (= total number of catalogued specimens) is an important consideration in judging the importance of a particular collection, other factors may also be taken into account, including taxonomic diversity, geographic representation, and historical collections (particularly type specimens). Using these criteria, smaller, regional holdings, particularly those that are national repositories, may be deemed important as repositories of turtle voucher specimens.

The prominent factors behind the acquisition of turtle specimens for a collection have been identified by this survey as individual research interests, as well as geographically determined turtle diversity and abundance. Critical for the advancement of knowledge, as well as for the continued existence and support for natural history museums, these specimens, once collected and accessioned into a curated collection, should be utilized for research and the museums and the specimens subsequently cited in publications (Suarez and Tsutsui 2004).

Traditional Voucher Specimens

As mentioned above, upon accessioning and cataloguing a traditional voucher specimen into a curated collection a minimal amount of information is required, however, it is critical that as much information be associated with the specimen as possible. For example, blood/tissue samples should be taken before the specimen is preserved, as well as photographs, recordings, etc. Table 1 provides examples of various voucher types and their characteristics.

Description of Species. — When a new taxon description (species or subspecies) is published or a revision to current classification is recommended, a voucher specimen should be deposited into a curated collection, whether the published evidence is based on morphological or molecular evidence or both. Although a (traditional) holotype specimen housed in a curated collection is not a mandatory requirement by the Fourth Edition of the International Code of Zoological Nomenclature for new taxon descriptions, it is nonetheless strongly recommended (Wakeham-Dawson and Morris, 2002; Dubois and Nemésio, 2007).

Table 1. Data characteristics and scientific value for various voucher types. In this table, the quality and reliability of the voucher increase in scientific value as one moves down the list. The value of all vouchers is increased with the inclusion of field notes, including habitat type, georeferenced locality data, date, collector, and standard measurements.

Voucher Type	General Category Data Characteristics	Scientific Value
No Voucher		
	Sighting/Description	Low
	Anonymous sighting	
	Specimen description	
	Drawing/illustration	
***e*-Voucher**		
	Image/Recording	Medium
	Single photo	
	Diagnostic audio recordings	
	Diagnostic video recordings	
	Diagnostic photos (series)	Medium-high
Voucher		
	Tissue	
	Blood/ tissue sample (no photo)	
	Blood/ tissue sample (with photo)	High
	Tissue samples (various organs; series)	
	Developmental tissue/expression library	
	Traditional Specimen Voucher	
	Diagnostic skeletal materials	
	Complete skeleton	Very high
	Fluid preserved complete specimen	

Genetic Studies. — When biological samples are used in systematic, taxonomic, and phylogeographic studies it is also recommended that traditional voucher specimens be accessioned and catalogued into a curated collection. Specimens used in such studies should be listed in a table, appendix or text along with the accompanying museum catalogue number (Ruedas et al., 2000). In these studies, independent verification of the identification of the taxon will most likely be required by researchers revisiting related questions in the future (Reynolds et al., 1994).

The importance of including voucher specimen information within publications is recognized by the Journal of Herpetology in its *Instructions to Authors* which "requires that all submissions from researchers reporting results of phylogenetic reconstruction and taxonomic decision be supplemented by in-text (if a shorter communication) or appendix (if a major paper) reference to voucher specimens" (http://www.ssarherps.org/pages/JHinstr.php).

Rare Animals in Captivity. — Animals housed in zoological parks, aquariums, and private collections offer the researcher a valuable resource and may provide the only readily available access to a specific taxon. Animals in captivity may also have associated data, including behavioral observations, veterinary records, and reproductive condition and history, that are not available from animals collected in the field and may be crucial to an interpretation of results. However, biological samples collected from living captive animals and used to generate data for scientific publications also pose a special situation with regard to voucher specimens and one for which the researcher must weigh the costs and benefits. Arrangements between the owner of the animal and a curated collection should be made for the disposition of the animal upon its death and it is recommended that all arrangements be made well in advance of the animal's demise (Lehn, 2005). It is also recommended that the animal be permanently marked, e.g., microchip or PIT tag, in order to ensure accurate identification in the future. A voucher specimen is also especially critical in those instances when provenance data are unavailable or unreliable, as is the case with many captive-held animals, including animals held by private collectors and/or purchased from the pet trade, food markets, or from animal dealers (Ruedas et al., 2000). Private collectors and zoological parks and aquariums should be encouraged to collaborate with a curated collection, especially in cases when very rare and/or endangered animals are being held.

Alternatives to the Traditional Voucher Specimen

Although it is optimal to collect a traditional voucher specimen in the field and preserve it in a curated collection, there are various reasons or circumstances when this may not be feasible or deemed ethical. In these situations nontraditional alternatives may be preferred. Examples of nontraditional vouchers may include image data (photographs, either digital or hardcopy), acoustic data, eggs and eggshells, and tissue samples (Monk and Baker, 2001).

To be valuable as a voucher specimen, a digital voucher (or *e*-voucher) should comprise an image showing the entire specimen and/or body parts diagnostic for taxon identification (Reynolds et al. 1996; Barkworth and Jacobs, 2001; Monk and Baker, 2001) (Fig. 1). One set of guidelines for the photodocumentation of turtles may be found in Bender (2001). In addition, a list of available resources for digital imaging and best practices may be found on the American Museum of Natural History's website (http://library.amnh.org/diglib/resources/index.html).

Limitations to Tissue Samples and DNA Barcoding. — Although providing a blood/tissue sample as the sole voucher for a molecular study is preferable to providing no voucher at all, these samples should be considered complements to the traditional voucher specimen and not alternatives (Peterson and Lanyon, 1992; Monk and Baker, 2001). By making the tissue sample available to the research community, future researchers are provided with the capability to repeat the molecular study, however, independent verification of taxonomic identification using morphological characters is impossible using such vouchers (Ruedas et al., 2000). An additional limitation associated with a tissue sample collected as a voucher is that its subsequent use is destructive and will lead to its eventual consumption, it is therefore imperative that the researcher collect tissue in amounts sufficient for the immediate needs of the research, as well as for the future needs of the community.

DNA barcoding promises to revolutionize taxonomic identifications by using a single gene sequence from the mitochondrial gene, cytochrome oxidase I (COI; Hebert et al., 2002) to uniquely identify species. At present, this is far

from being a reality for many taxa, including turtles. GenBank's® database currently holds only 107 sequences for turtles for this mitochondrial gene and only 23 species in 4 genera are represented. All of these sequences have associated voucher specimens, however the majority of these vouchers (58/107) are tissue samples. The barcoding initiative will only be useful when all taxa from all geographical regions are represented by sequences and will then only be useful to the extent that voucher specimens are available and at the appropriate taxonomic level. Additionally, since the mitochondria are inherited only through the maternal lineage, the barcoding of a mitochondrial gene may not always be useful for the identification of hybrid individuals (Karl et al., 1995), which may be particularly relevant for some turtle taxa [but see Spinks et al., 2004 and Stuart and Parham, 2004 for examples when mitochondrial DNA was useful in identifying hybrid individuals].

Population Studies. — An example when a traditional voucher specimen is not feasible or recommended from each individual is for population genetic and phylogeographic studies when potentially hundreds of biological samples across the range of a single taxon may be collected. In these studies, researchers usually avoid sacrificing entire individuals by using minimally invasive or non-lethal sampling techniques to collect blood, skin, tail tips, shell, or toe clips (Haskell and Pokras, 1994). It may be appropriate to collect a traditional voucher specimen from a representative individual for a locality or region. We strongly recommend, however, that researchers consider exhaustively *e*-vouchering each individual from which a sample has been taken. This will allow for independent verification of species identification of all samples included in the study. In cases where exhaustive *e*-vouchering is not possible or too laborious, we recommend that a photograph be taken of individuals representative of the population, e.g., at each collection locality, and of color or morphological variants. This practice will alleviate problems that may arise subsequently with closely-related taxa being inadvertently misidentified and sampled and will greatly assist identifications in those cases when individuals are genetically divergent from all others in the study.

Damaged Specimens. — A traditional voucher may also not be possible when genetic samples are taken from heavily damaged or partially degraded roadkills or other unsalvageable specimens. In such instances, if genetic samples are taken, the dead animal should be photographed and standard collection notes and locality data (including georeferenced positional data, if possible) should accompany the photo (Monk and Baker, 2001). Additionally in these instances, any salvageable portion of the specimen (e.g., the skull) should be collected and deposited in a museum whenever possible.

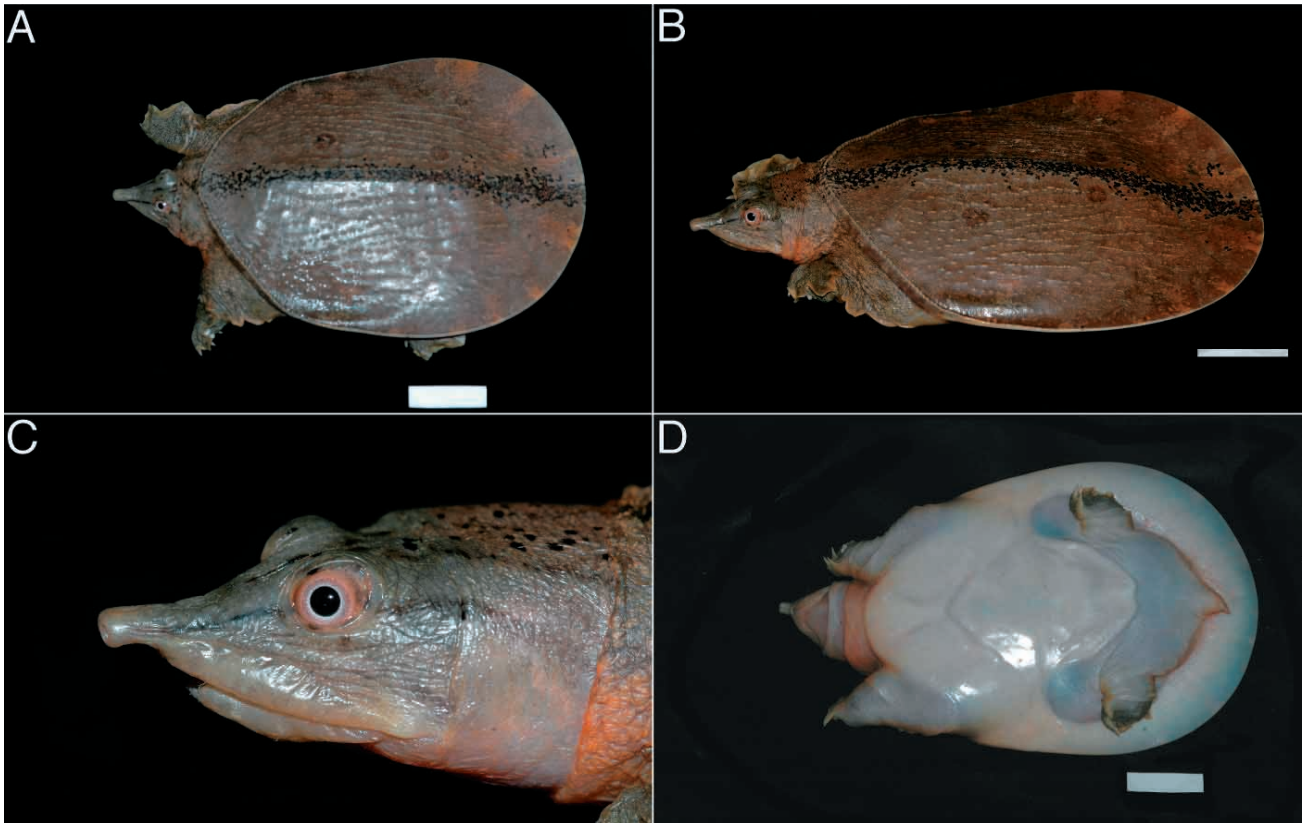

Figure 1. Example of a digital voucher and associated data for a turtle specimen. *Dogania subplana*, subadult male (straight carapace length = 102.3 mm; straight carapace width = 83.1 mm; measurements including cartilaginous flap), from Sungei Pueh (01°43'38.5''N, 109°43'25.7"E, datum WGS 84), near Kampung Sebako, base of Gunung Pueh, Sematan District, Kuching Division, Sarawak, Malaysia (Borneo). USDZ [IMG] 2.63. Body in dorsal **(A)** and lateral **(B)** views; lateral view of head **(C)**; and ventral aspect of plastron **(D)**. Scale markers = 20 mm. Photos: I. Das.

Storage or Handling Concerns. — It may also not be feasible to collect traditional specimens from extremely large specimens because of storage space concerns in the museum's collection (Gans, 1989) or for handling in the field, in these instances a digital voucher can be a suitable alternative to a traditional voucher specimen.

Living specimens. — Captive collections of living animals may provide very valuable resources for the researcher and considerations to be taken at the time of the animal's death have already been discussed. However, biological samples collected from living animals and used to generate data for scientific publications also pose a special situation with regard to traditional voucher specimens (Monk and Baker, 2001). In these instances, the live animal should be fully photo-documented, PIT tagged or marked by some other unique or individual-specific identifying means, and an aliquot of the sample along with images and accompanying data should be deposited into a curated collection.

In some cases, a natural history museum may not be willing to accept or even be capable of accepting captive specimens for reasons such as storage constraints, a lack of data associated with a captive animal, or the destruction of critical characters during necropsy and it is in these circumstances that non-traditional vouchers are extremely valuable (Monk and Baker, 2001).

As stated above, the impact on the population from collecting animals for preservation is usually minimal, however, there are cases when the number of individuals of a given taxon that remain alive are so low that the collection of even a single animal may reduce the probability of its continued survival. One well-known example is the case of "Lonesome George" (*Geochelone* [= *Chelonoidis*] *nigra abingdoni*), the sole survivor of his subspecies (Nicholls, 2004; Fig. 2). We recommend that in these rare cases, non-traditional vouchers, especially photographic vouchering (accompanied by complete data), be collected and arrangements be made prior to the death of the animal to have it preserved in a curated collection immediately following its death.

Regulatory Restrictions. — There are numerous regions and protected areas where collecting biological specimens is prohibited by local law, but where the collection of non-traditional vouchers may be possible (Prendini et al., 2002). In cases where specimens are sampled from protected areas or where a researcher wishes to document the presence or distribution of a species that cannot be collected, *e*-vouchers are recommended. One might also envision cases where researchers make incidental or unexpected observations and where collecting the animal at that particular time may be illegal or otherwise unfeasible. In these instances images in the form of *e*-vouchers are preferable to no documentation at all.

Legal and Ethical Concerns

Any time a traditional or non-traditional voucher is taken from an animal it is imperative that it is done legally and in a humane fashion. In today's international environment, there will be circumstances when collecting permits may not be granted by particular countries or permit-issuing authorities (Prendini et al., 2002). If researchers wish to document the distribution of species or the occurrence of a given species in a particular area of interest, the alternative to collecting may be to adopt non-traditional vouchers. All vouchered specimens, whether traditional vouchers or tissue samples, must be accompanied by the appropriate permits. If possible, every attempt should also be made to deposit a portion of the collected specimens into curated collections within the country of origin (Reynolds et al., 1996). A more thorough discussion of the legal and ethical concerns associated with the acquisition of animals for research may be found in Burke et al. (2007).

Summary and Conclusions

A traditional voucher specimen for a turtle consists of a fluid-preserved specimen or a complete skeleton and its associated data appropriately preserved for permanent stor-

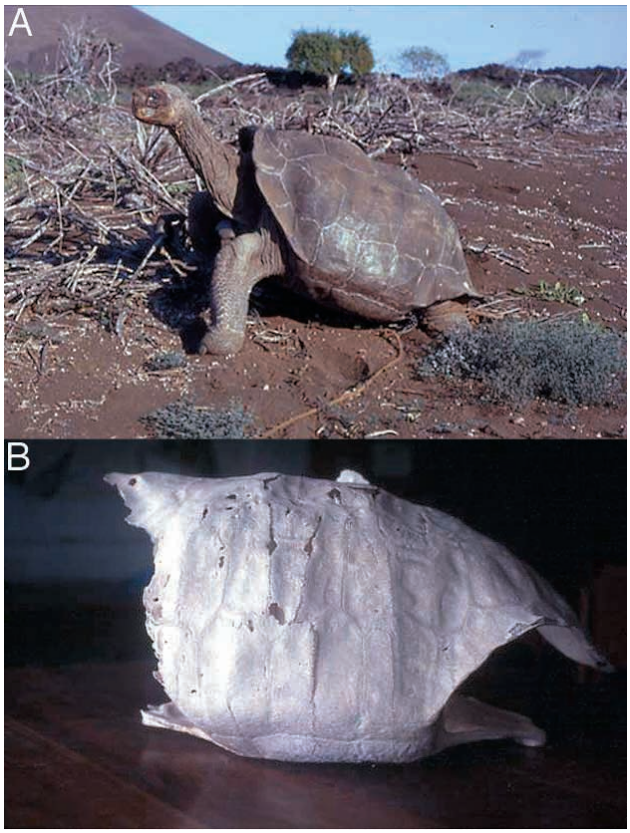

Figure 2. A. The sole survivor of the Abingdon Island tortoise (*Geochelone* [= *Chelonoidis*] *nigra abingdoni*), a subspecies classified by IUCN as Extinct in the Wild. This photograph was taken shortly before this individual was removed from Pinta Island in 1972. The plight of this individual animal, popularly dubbed "Lonesome George," is often evoked during debates of the many ethical and philosophical issues associated with collection of voucher specimens in turtle systematics and taxonomy. **B.** The bony shell of a specimen of *G. n. abingdoni,* found on Pinta in 1964 and deposited in the collection at Charles Darwin Research Station. Photos courtesy of P. Pritchard.

age and housed in a curated collection for posterity. The importance of voucher specimens has been documented and appreciated by researchers in various disciplines for many years, however, the practice of vouchering is still far from routine for researchers working on turtles. Many reasons may account for reluctance by researchers to sacrifice animals for preservation in a curated collection, however, the value of such specimens for taxonomic verification and repeatability of research in addition to the provisions of future research far outweigh many concerns. Digital photography provides a viable option for non-traditional vouchering techniques, particularly in the case of population studies involving large numbers of individuals. In addition, researchers collecting samples from captive collections should also be aware of the importance of obtaining voucher specimens. There are instances when there is no truly adequate substitute for the deposition of a traditional voucher specimen into a curated collection, e.g., new taxon descriptions and phylogenetic studies. It is our hope that a strong emphasis on the importance of voucher specimens by professional colleagues and journals will strengthen an appreciation by the research community on the importance of voucher specimens for responsible science.

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APPENDIX I

Contents of the reptile collections of natural history museums in Africa, Asia, Australia, Europe, North and South America, that responded to an email survey conducted between September - December 2005, showing the proportion of turtles represented[1]. Museum abbreviations after Leviton et al. (1985; 1988), where available; other abbreviations may be found in the Acknowledgments. Asterisk (*) indicates approximate numbers.

Museum (Country)	Total Reptiles	Total Turtles	% Turtles
AMS (Australia)	116,000	2,411	2.1
AMNH (USA)	149,687	8,527	5.7
BMNH (UK)	120,000*	4,000*	3.3*
BNHM (India)	5,070*	90	1.8*
CAS (USA)	168,374	2,464	1.5
CRI (USA)	11,450	11,450	100.0
CIB (China)	14,300*	185	1.2*
CM (USA)	88,109	28,652	32.5
FHGO-USFQ (Ecuador)	3,537	30	0.8
FML (Argentina)	20,550	77	0.4
FMNH (USA)	118,167	5,870	4.9
FRIM (Malaysia)	578*	1	0.2*
HNHM (Hungary)	3,163	145	4.6
HUJ (Israel)	21,000*	539	2.6*
KRSU(Kyrgyzistan)	4,589	31	0.7
KU (USA)	131,730	5,249	4.0
KUZ (Japan)	47,000*	350*	0.7*
LSUMZ (USA)	88,791	3,672	4.1
MCN (Brazil)	2,157	23	1.1
MCZ (USA)	183,977	4,517	2.5
MHNG (Switzerland)	34,800*	658	1.9
MHNLS (Venezuela)	6,000*	61	1.0
MLP R (Argentina)	5,200	61	1.2
MNKhNU (Ukraine)	10,000*	100*	1.0*
MNHN (France)	110,000*	3,700*	3.4
MSNM (Italy)	4,004	774	19.3

MVZ (USA)	99,031	2,840	2.8
MZB (Indonesia)	8,902	336	3.8
NMK (Kenya)	8,100	94	1.2
NHM (Denmark)	407	36	8.8
NHMC (Crete)	5,000*	100*	2.0*
NHMK (Nepal)	530*	17	3.2*
NMB (Switzerland)	23,400	817	3.5
NMW (Austria)	40,640	5,170	12.7
NMNS (Taiwan)	4,500	130	2.9
NSMT (Japan)	38,000*	86	0.2
NTNU (Norway)	250*	10	4.0
OMNH (Japan)	2,200*	34	1.6*
PEM (South Africa)	17,000*	1,109	6.5*
PNHM (Pakistan)	2,000*	35	1.8*
PNM (Philippines)	4,000*	128*	3.2
QM (Australia)	43,011	1,853	4.3
RBINS (Belgium)	51,120	1,143	2.2
RMNH (Netherlands)	34,060*	4,000*	11.7*
ROM (Canada)	16,310	1,060	6.4
RUZM (Iran)	4,000*	45	1.1*
SBC (Malaysia)	111	2	1.8
SM (Malaysia)	1,728	182	10.5
SMF (Germany)	87,000*	4,000*	4.6*
SNHM (Germany)	5,000*	80	1.6
TAU (Israel)	14,422	740	5.1
TMU (Norway)	38	3	7.9
TNHC (USA)	31,088	1,672	5.3
UF (USA)	80,513	11,211	13.2
UMMZ (USA)	134,421	8,904	6.6
USDZ (Singapore)	6,165	398	6.5
USNM (USA)	175,388	18,513	10.6
VNM (Vietnam)	5,650*	150*	2.7*
WHT (Sri Lanka)	1,400*	0	0
YPM (USA)	15,049	1,027	6.8
ZDEU (Turkey)	13,936	426	3.1
ZMA (Netherlands)	15,000–20,000*	506	3.4–2.5
ZMB (Germany)	70,000*	2,600	3.7
ZMH (Germany)	35,000*	1,200*	3.4*
ZMUC (Denmark)	40,000*	700*	1.8
ZSI (India)	25,622*	1,173	4.6*

[1]Carnegie Museum of Natural History (28,652 specimens, representing 32.5%), reported the highest number and proportion of turtles (except for CRI at 100%), which is composed mostly of embryological specimens from the work of its late Curator, Clarence McCoy, 1935–1993 (see Bull et al., 1982; Vogt et al., 1982; McCoy et al., 1983). Another large collection of mostly hatchling turtles was received by Carnegie Museum from the embryological work of Michael A. Ewert (1938–2005), but these are yet to be accessioned in the collection (S.R. Rogers, *pers. comm.*). Other collections with large holdings of turtles also represent a special interest in the group by one or more former staff, e.g., at the United States National Museum, Leonard Stejneger, and more recently, Carol Ruckdeschel, Jack Frazier, George Zug and Tom Fritts [G. R. Zug, *pers. comm.*], at the Florida Museum of Natural History, Walter Auffenberg, Archie Carr, John Iverson and Peter Meylan, and at the Naturhistoirisches Museum, Wien, Friedrich Siebenrock (1853–1925). Three respondents mentioned a lack of funding support for their collections, hence the charge of herpetology given to other Divisions. One major herpetological collection in Vietnam has no official status, and therefore its contents are to be dispersed after the studies by its collector are completed. The survey did not specifically inquire about sea turtles, and suspect that this group, in addition to other large-bodied group of turtles (e.g., gigantic members of the Testudinidae and some Geoemydidae) would be relatively underrepresented in collections. Gans (1989) mentioned that museum curators are averse to accepting large turtles and crocodilians in their collection, with the result that most of the studies on internal anatomy of these species have been conducted on juvenile specimens.