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Calamities causing loss of museum collections: a historical and global perspective on museum disasters

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Abstract

With alarming frequency, significant collections in natural history museums have been destroyed or damaged through insurrections, cyclones, wars, fires, floods, or earthquakes particularly in the nineteenth century but continuing into the twentieth century with World War II bombings, fires, and earthquakes being the primary causes of loss in fifty-seven institutions across thirty countries. We review the loss or damage of museum collections globally, and their varied causes. We emphasize the benefits of dispersal of a sample of paratypes across institutions as an essential feature of taxonomic practice. We argue that museums do not own type material but are acting as perpetual custodians of type material on behalf of science and society in general, and that museums, therefore, have an obligation to minimize the risk to their collections. The significance of the loss of type material would be ameliorated if, when there are numerous paratypes or syntypes, members of a type series were distributed among several institutions. This is currently common practice but historically this was not always the case and might not be possible if only a single holotype is available. We also reaffirm the need for scientists around the globe to develop specific protocols to protect collections of biological and cultural materials from loss or damage from natural and human-created disasters now and into the future. We comment on recent moves to modify the Zoological Code of Nomenclature to allow the use of images as "type" material when describing new species with the image serving as a substitute for "physical" specimens deposited in museum collections. Although our focus is on herpetological collections, our particular interest and area of expertise, our observations apply broadly to all collections, including those of animals, plants, and anthropological or ethnographic material.

Key words: Herpetology, museum disasters, type specimens, taxonomic practices

Introduction

Natural history museums and herbaria are repositories for specimens that form the basis, and serve as a formalized catalogue, of much of our present understanding of biological diversity. The basis of animal taxonomy is enshrined in the International Code of Zoological Nomenclature (1999). When new species are described, the Code requires the designation and description of one specimen as the holotype, and desirably, a series of one or more paratypes. The distribution of paratypes to institutions other than that housing the holotype specimen is a highly desirable element of taxonomic practice, often, but not always followed, and might not be possible if insufficient specimens are available. This geographic and institutional spread of type material allows broader access to "type" material, but more particularly, acts as insurance against loss of types resulting from unplanned and unpredictable disasters, e.g., wars, fires, floods, cyclones, earthquakes, or tsunamis that might affect the institutions housing the type specimens. If an entire type series is lost a neotype can be designated. A neotype is "the name-bearing type of a nominal species-group taxon designated when no name-bearing type specimen (i.e., holotype, lectotype, syntype, or prior neotype) is believed to be extant and an author believes that a name-bearing type is necessary to define the nominal taxon objectively" (International Code of Zoological Nomenclature, 1999: 84).

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We discuss the development of natural history collections, their transformation into modern museum collections, and the long-term safety of natural history museums, their contents, and their register records of collections. Our focus is herpetological collections, because that is our collective area of expertise, but our comments apply broadly to all animal taxonomy. Loss of type material and register records of collection content are rarely mentioned in the literature, though, as we show below, the risks to both are high.

Acording to the Merriam-Webster's Dictionary (https://www.merriam-webster.com/dictionary/museum; accessed 02 October 2021), the word "museum" is derived from the Greek *mouseion*, being a place for muses or study. The Concise Oxford Dictionary (museum noun - Definition, pictures, pronunciation and usage notes | Oxford Advanced Learner's Dictionary at oxfordlearnersdictionaries.com (accessed 02 October 2021) refers to the role of a museum as storing and displaying objects.

The origin of "museum," to describe a place holding and displaying objects was preceded by cabinets of curiosity or Naturalienkabinette. According to Beck (2018) "Scientific museums" were inspired by the "cabinets of curiosities" and "cabinets of wonder" of the sixteenth, seventeenth, and eighteenth centuries, established and prized predominantly by "the nobility, well-travelled merchants, or scholars." Although such cabinets showcased plant specimens, animal specimens took center stage and were arranged according to their aesthetic qualities, as well as containing objects that provided some scientific insight, such as models and experiments (Mauriès 2002; Davenne & Fleurent 2012). What most people recognize today as modern museums are the evolved cabinets of curiosity: natural history collections, which have undergone profound developments (West 2014; Carlins 2015).

As well as private collections, there is also a very long history of museums associated with universities. For example, Håkansson (2020: 443) discussed the Museum Stobaeanum founded at Lund University, Sweden, in 1735 by Kilian Stobaeus, who is "best known as the teacher of Carl Linnaeus." Håkansson (2020) also referred to several other museum collections held by universities at that time.

Linneaus and his advocacy of a binomial nomenclature system provide a link to current taxonomic practice where new animal species currently are defined by a type specimen with, desirably, a series of one or more paratypes (International Commission on Zoological Nomenclature 1999). The type specimen and a type series are defined when a species is described and are normally held in formal museum collections. Globally, there are at least 2,064 distinct collections containing herpetological, or herpetological plus ichthyological material, in 155 countries (Sabaj Pérez 2020).

There are recent moves by some to use digital images to represent type material, instead of physical specimens (Marshall & Evenhuis 2015), but there is also strong opposition to such suggestions (Ceríaco *et al.* 2016). If digital images were accepted in place of, or as an adjunct to, whole specimens in future taxonomic practice, the issues we discuss here for conventional whole specimen collections will also apply to electronic repositories. They are subject to many of the same risks we discuss here for the management of traditional collections, with the additional risk, we presume, that they might be hacked and deleted or modified, but with the considerable advantage that they can be easily replicated and stored at multiple sites. This raises additional issues of the image format to be used, the durability of that format, how to maintain the integrity of the storage medium (Vollmar *et al.* 2010), and how images relate to other relevant data types, e.g., DNA sequence data or morphological data; such issues are discussed in detail by Miralles *et al.* (2020). Hard copy or digital images can serve as a valuable complement to verbal descriptions, e.g., particularly of color or morphological features that may be difficult to describe but they preclude individual re-interpretation or review of morphological characteristics of the original specimens that may lead to the recognition of characters previously missed (Türkay *et al.* 2018).

Current specimen collections are critical, as an unchangeable reference, and must be safeguarded for use in perpetuity (National Academy of Sciences, Engineering, and Medicine 2020). Importantly, the issues we discuss for conventional whole specimen collections will also apply to electronic repositories, as they are subject to all of the same risks we discuss for the management of traditional collections.

In the management of herpetological collections, type specimens and type series are commonly initially fixed in formalin-based solutions but stored long-term in ethyl alcohol solutions. Tissues that might be used for future DNA-based investigations have been stored in the recent past in ultra-cold freezers and are now commonly held in alcohol-based solutions. The use of alcohol for fixation and preservation of whole animals and soft tissue samples heightens the risk of fire, which is potentially catastrophic when thousands of liters of alcohol are stored in one place; fluid volumes are commonplace in natural history museums. The physical location of museums may also generate risk. Floods, e.g., from nearby rivers or storm water flows may inundate specimens stored in basements

with a risk that external labels will be detached and lost. Seismic disturbance, with or without an associated tsunami, is a significant risk in several countries and led to the death of the entire staff of the Rikuzentakata City Museum in Japan (Suzuki Mahoro, pers. comm., 7 February 2022). Devices have been developed that accommodate the shaking created by earthquakes that could ameliorate this risk, but these appear to have been developed particularly for protection of cultural objects, e.g., for individual pottery items or sculptures, not animals preserved in multiple, alcohol-filled glass jars. During the Second World War, many collections were moved to remote locations, limiting their exposure to damage from hostilities or theft by invading troops but relocation increases the risk of material being lost or misplaced.

To prepare this manuscript we contacted personnel in natural history museums in particular, and many other colleagues across the globe; their names are listed in the acknowledgements. We located publications that summarized details of damages incurred at various natural history museums. Crumly (1984) and particularly Beck (2018) summarized damage to German natural history museums during World War II and monographs by Rieck *et al.* (2001) and Bischoff (2018) provide further details of World War II impacts on collections. Lenzi (2004) assembled a detailed guide entitled "Museums of Southeast Asia," but did not include a single natural history museum, with two noteworthy omissions, i.e., the Bogor Zoological Museum in Indonesia and the Raffles Museum in Singapore (Das & Lim 2001).

We provide brief notes on the history of the institutions that we know to have suffered catastrophic loss and draw attention to the risk of wholesale loss of entire type series. We emphasize the benefit, when specimen numbers permit, of ensuring perpetuity of physical material by the dispersal of paratypes among several institutions.

We emphasize, however, that we have catalogued museum disasters – we have not attempted to produce a comprehensive list of lost or missing type material. The specific documentation of lost or missing type specimens is a task for individual collection managers. We encourage them to do so and to ensure that those data are reported in services such as Amphibian Species of the World 6.1, an online reference (https://amphibiansoftheworld.amnh.org/; accessed 23 September 2022) and The Reptile Database (http://www.reptile-database.org/; accessed 23 September 2022).

Results of Survey

By country, in alphabetical order, we obtained information from 30 countries, including Afghanistan, Australia, Austria, Azerbaijan, Belgium, Brazil, Chile, Croatia, Czech Republic, England, France, Georgia, Germany, Hungary, India, Italy, Japan, Libya, Malaysia, Mexico, Netherlands, New Guinea, Nicaragua, Philippines, Poland, Portugal, Romania, Russia, Ukraine, and the Unites States of America. Our coverage includes museums where we know of loss of type material, but also museums where collections have been damaged and are, or have been, at risk.

In several cases we have used web-based sources because we could not locate any formal scientific or other forms of publication. The acknowledgments contain an extensive list of individuals who provided us with information about specific museums and impacts on them.

AFGHANISTAN: KABUL MUSEUM, KABUL

The first collections made in Afghanistan appear to date from the mid-nineteenth century. These were identified and reported by G.A. Boulenger of the British Museum. A century later, Knut Lindberg from Sweden made several collecting trips from 1947 onwards. Wagner *et al.* (2016) gave a historical account of Afghan herpetology and concluded that the Afghan herpetofauna consists of 118 species and subspecies representing 58 genera and 21 families with seven endemic species. They removed 18 taxa from previous lists.

Several wars have limited when fieldwork could be undertaken in Afghanistan. The most recent field activity was probably conducted by the late Clas M. Naumann (Zoological Research Institute and Museum Alexander Koenig, Bonn; Kasparek *et al.* 2004), who was appointed Professor in the Faculty of Science at the University of Kabul from 1970 to 1972. He and other German biologists established a zoological museum at the university.

Naumann's collections were identified by colleagues at the Museum Koenig, Bonn, and ultimately divided equally between the museums at Bonn and Kabul. One voucher of each species, however, had to stay in Kabul, including unique vouchers of rare species. The destruction of both the Zoological Museum and the Zoological Garden started during the civil war with heavy combat operations in Kabul and on the university campus. The collections

and buildings were finally destroyed during the Taliban regime. This destruction also included the "Herbarium Kabulense," the most important collection of the Afghan flora (Philipp Wagner, pers. comm., 12 December 2021). We do not know the current condition of museums and collections in Afghanistan.

AUSTRALIA: NORTHERN TERRITORY MUSEUM, DARWIN

In December 1976, Cyclone Tracy struck Darwin, with extensive damage caused to many structures across the city. Although Cyclone Tracy was initially expected to pass over Darwin without damage, it suddenly changed direction and became a Category 4 Severe Tropical Cyclone, with wind gusts up to 217 kilometers per hour. Cyclone Tracy killed 71 people and destroyed more than 70 percent of Darwin's buildings, including 80 percent of its houses.

Gavin Dally, Senior Collections Manager, Natural Sciences, at the Museum and Art Gallery of the Northern Territory, informed us that in 1974 the "Old Town Hall," built of stone in 1883 in central Darwin, housed the Northern Territory Museum ethnographic art, and historical collections and a public display of ethnographic objects. This building was destroyed by Cyclone Tracy and many objects were lost.

There was a 1940's era building next door (the Old Naval store) that housed the laboratory, offices, and other collections, including natural history collections (Figure 1). This building was left standing after the cyclone but received extensive damage. Half the roof came off and the walls were cracked, but the contents survived intact, including the natural history specimens. The building was later demolished. At that time, the herpetological collection was probably small, as its first curator, Graeme Gow, only started work in April 1974. All specimens in freezers were salvaged, with very little loss, including material that was intended for skeletonization or for genetic analyses (Gavin Dally, pers. comm., 29 June 2020).

FIGURE 1. Remains of Darwin Museum after Cyclone Tracy in 1974. The Old Town Hall (right) was destroyed, with the Naval store left standing. Courtesy of Gavin Dally, Senior Collections Manager, Natural Sciences, Museum and Art Gallery, Darwin, Northern Territory, Australia.

AUSTRIA: TIROLER LANDESMUSEUM, INNSBRUCK

Constructed by Kaiser Maximilian I as an arsenal in 1502, the building now known as the Tiroler Landesmuseum served various purposes for a period of several hundred years before becoming a museum for both storage and display in 1823. On 6 August 1985, the building was flooded. Tarmann (1999) observed the flood, describing it graphically, as follows: "After two days of heavy rainfall the rivers in Tyrol were no longer able to hold the excess water, flooding extensive parts of the country. This had happened several times before but, owing to river regulations, the flooded areas were mainly outside the towns and villages. This time, it was different. Years of devastation to mountain slopes and the restriction of creeks and rivers to a minimum breadth to gain land for cultivation, ski pistes, or building activities had changed the country to a 'point of no return' and nature started to fight back. It was about 1:30 pm when the water reached the museum building. It rushed through the open entrance door but also came out of the ground in fountains from the drains and sewers. The volume of water and the power of the flood were so

strong that it was impossible to immediately plan any rescue activities for the collections. The 40m x 70m courtyard was completely covered with water within a few seconds. The strong current flowing from west to east made it impossible to close the Museum's front door. The ground floor offices with parts of the collections were submerged a few minutes later, accompanied by an earthquake–like shaking and a sound of thunder that came from the wall of water falling against the basement hall where about 80% of the collections and parts of the library were stored." A few herpetological specimens were destroyed but their details are unknown.

AZERBAIJAN: AZERBAIJAN NATIONAL ACADEMY OF SCIENCES, BAKU

The National Academy was organized as the Azerbaijan Society for Scientific Research and Studies, initially associated with Baku State University, and later with the USSR Academy of Sciences. By 1923, the National Academy had become the principal scientific organization in the country. In 1929 there was a reorganization into Azerbaijan State Scientific Research Institute and in 1932 yet another change to become the Azerbaijani Branch of the Trans-Caucasian Affiliate of the Academy of Sciences of the USSR.

In 1945 the USSR Council of People's Commissars became involved in museum nomenclature and ordered yet another name change to the Academy of Sciences of the Azerbaijan SSR. A presidential decree on 15 May 2001inserted "National" in front of that title.

Natalia Ananjeva (pers. comm., 11 August 2019) reported most of the collections are extremely vulnerable. Social tension, coupled with a sharp decline in the funding of science, alongside social instability after the collapse of the USSR, has resulted in poor attention to collections. Tavakkul Iskenderov Muxtar, of the Azerbaijan National Academy of Sciences (pers. comm., 29 December 2019), reported that unrest meant there were no funds available to buy alcohol needed to maintain the collection of preserved lizards. Plundering has also contributed to loss of herpetological collections.

BELGIUM: ROYAL BELGIAN INSTITUTE OF NATURAL SCIENCES, BRUSSELS

Currently, the repository of a substantial collection, the Institute has always functioned as a museum and has had a mixed history attributed to the linguistic separation of Flemish and French–speaking components of the community. The French invasion of 1794 led to pillaging and dispersal of the collections.

Since the 1940's, the herpetological material has been held in a secure tower building named "De Vestel" after its architect, which, being at that time the highest in Brussels, was equipped with a rooftop anti-aircraft gun from July 1940. Despite this becoming a strategic target, it was not hit in allied air raids, avoiding damage to the collections beneath (Olivier Sylvain Gérard Pauwels, pers. comm., 22 August 2019).

BRAZIL: NATIONAL MUSEUM OF BRAZIL, RIO DE JANEIRO

Founded by King John VI of Portugal in 1818 as the Royal Museum, the destruction of the National Museum of Brazil by fire on 2 September 2018 was, by world standards, a major loss. The museum contained an estimated 20 million items (Phillips 2018). Located in a building that had served for a period as temporary palace accommodation for the Portuguese Royal Family fleeing from the Napoleonic forces, the fire rapidly developed into an inferno that was hot enough to break rock (see https://www.theguardian.com/world/2018/sep/03/fire-engulfs-brazil-national-museum-rio; accessed 1 April 2022). Most of the vertebrates in the building were fossils. Specimens preserved in alcohol were kept elsewhere. The larger fossils in unprotected positions were lost. They included the most complete collection of pterosaurs, i.e., flying reptiles with elaborate skull ornamentation. Until the fallen metal cabinets housing smaller creatures are opened, we will not know whether any herpetological specimens have survived. The usual paper and cardboard labels or painted numbers identifying them are likely to have been destroyed. In addition to the museum collections from Brazil, two syntypes of the Rough Frog, *Hylomantis aspera* of Bahia, Brazil, on loan from the Berlin Museum, were also destroyed (Frank Tillack, pers. comm., 26 January 2022).

Zoologist Paulo Buckup informed BBC Brasil's Julia Carneiro, however, that "a few thousand" mollusk specimens, which included 80 percent of the museum's holotypes were rescued (see https://www.smithsonianmag.com/smart-news/these-are-latest-updates-brazils-devastating-national-museum-fire-180970232/; accessed 06 January 2022).

Phillips (2018) suggested the cause of the fire was unknown, but the Smithsonian Magazine of April 9, 2019, reported that "an improperly installed air conditioning unit on the ground floor of Brazil's National Museum ignited the blaze" (see https://www.smithsonianmag.com/smart-news/faulty-air-conditioning-unit-sparked-devastating-brazil-national-museum-fire-180971903/; accessed 06 January 2022). The lack of hoses, water sprinklers, and fire

doors meant that the building was protected by only a few fire extinguishers; the National Museum only allocated $4,000 for safety equipment between 2015 and 2017 (Solly 2019). The loss of cultural and biological treasures of the immense value of those in the National Museum of Brazil has been attributed to the financial under-resourcing of the museum by the Brazilian government over many years (Phillips 2018; Felipe Gobbi Grazziotin, pers. comm., 22 May 2019).

BRAZIL: INSTITUTO BUTANTAN, SAO PAULO

The Instituto Butantan of Sao Paulo is one of the world's major medical research laboratories devoted principally to the study of venomous animals and the production of antivenins. In addition to the collection of live snakes milked to produce antivenoms, the Institute maintained a collection of 85,000 preserved snake specimens, including many rare or extinct species stored in ethanol and used for reference and research (Warrell *et al.* 2010; Kmech 2010). This institution also housed a collection of 450,000 spiders and scorpions (Warrell *et al.* 2010). Instituto Butantan is a large organization with more than 2,000 staff. The Institute was founded in 1901 by the physician Vital Brazil in response to an outbreak of bubonic plague in the city of Santos (Kumar 2010), and has now become a major pharmaceutical manufacturer with the sale of vaccines largely responsible for its financial support. In 2018 it produced two million doses of various vaccines.

This fabled institution and its collection of inestimable value was destroyed by fire on 15 May 2010. The fire was fueled by the alcohol used for preservation and storage (Warrell *et al*. 2010). Live animals used for the production of serum and vaccines, were not harmed (Kumar 2010). There was neither a fire alarm nor a sprinkler control system in the building (Kumar 2010; Figure 2).

The destruction of the Butantan collection of preserved venomous animals gives rise to a spectrum of fundamental questions about the value of such collections as these. How and why could such destruction be allowed to occur? Damages brought about by so-called "natural disasters" are less controllable than human-caused disasters, but how could a fire be allowed to destroy a collection of preserved animals as valuable as that of the Instituto Butantan? This institution might not be as well-known as some cultural structures but imagine the outcry if institutions like the Louvre Museum in Paris, France, the Taj Mahal in Agra, India, the White House in Washington, USA, or the Sydney Opera House in Sydney, Australia, were burnt to the ground. The Instituto Butantan collections represented over one hundred years of effort by biologists to catalogue the biodiversity of the South American continent. In the wake of the fire's destruction, widespread outrage was expressed, especially directed toward officials of the government who were unaware of the value of the collections in the Butantan Institute, nor of the need for the provision of relatively simple protective measures against fire damage (fire alarms and sprinkler systems), and other sorts of disasters that conceivably could strike the Institute (Sant'Anna 2010). In the wake of the destruction "the misery is intellectual, and the poverty will be endless" (Sant'Anna 2010: 399).

CHILE: MUSEUM OF ZOOLOGY, UNIVERSITY OF CONCEPCIÓN, CONCEPCIÓN

Founded in 1919, the private University of Concepción experienced the 2010 earthquake that also destroyed the Chilean National Museum. The earthquake caused jars to be dislodged from shelves and smashed. Alcohol from broken jars flowed down the stairs from the fifth floor where the herpetological collection was located. We have been unable to obtain details of the material represented in the collection and, consequently, whether any specimens were lost (Marcella Vidal, pers. comm., 3 June 2019).

CHILE: THE NATIONAL MUSEUM OF NATURAL HISTORY, SANTIAGO

The National Museum of Natural History was founded in 1830 on the advice of French naturalist Claudio Gay, who was commissioned by the Chilean Government. Due to their national economic significance, the initial focus was on crops and mineral resources with particular emphasis attached to copper, which was mined extensively. The museum building was constructed in 1875 for the promotion of the Chilean International Exhibition but zoological material was not included in the collection until 1889.

The museum was damaged by earthquakes, in 1906 and 1920, but the impact of a severe earthquake in 2010 was most destructive, causing the institution to be closed for repairs for almost four years (Marcela Vidal, pers. comm., 3 June 2019).

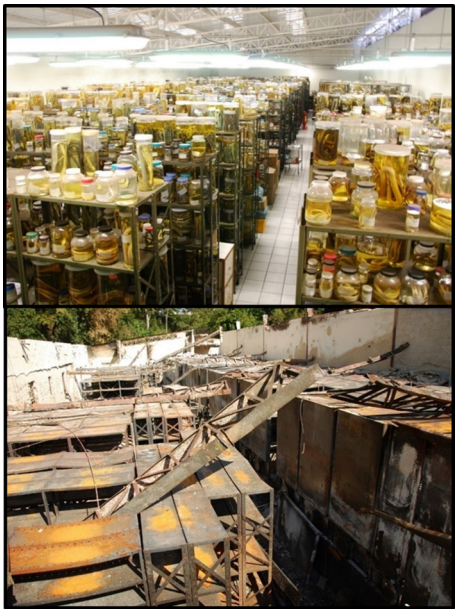

FIGURE 2. View of the collection of animals preserved in alcohol in the Instituto Butantan, Sao Paulo, Brazil before (upper) and after (lower) the fire in 2010. Courtesy of Marcelo Ribeiro Duarte (Instituto Butantan).

CHILE: INSTITUTE OF ZOOLOGY, AUSTRAL UNIVERSITY, VALDIVIA

The move to establish a private university at Valdivia, Chile, was the main objective of the Sociedad de Amigos del Arte formed in 1942. With financial support from influential members of the public, the university was founded in September 1954 and inaugurated in March of the following year. The university slowly increased its sphere of activity, including the establishment of a Museum of Zoology.

In December 2007 on Tesa Island, several scientific departments became engulfed in flames, including that housing important amphibian collections. The fire was accompanied by highly toxic smoke, resulting in the evacuation of 10,000 inhabitants.

The fire destroyed the entire collection of Amphibia, including all species described for Chile and included in the collection, i.e., endemic frogs of the Chilean Andes (*Telmatobius)* and the temperate *Nothofagus* forests of the extreme south of Chile and Argentina (*Alsodes, Batrachyla, Calyptocephalella, Eupsophus, Hylorina, Rhinoderma,* and *Telmatobufo*). The collection had 3,502 adult specimens, 132 larval series, and 65 dried and cleared-and-stained skeletons.

Despite being a comparatively small collection, it contained 15 holotypes (28% of the frogs described for Chile). Holotypes destroyed were those of *Telmatobius dankoi, T. vilamensis, T. chusmiensis,* and *T. philippi, Batrachyla nibaldoi, Eupsophus emiliopugini, E. migueli and E. altor, Telmatobufo australis, Alsodes australis, A. hugoi, A. norae, A. kaweshkari, A. valdiviensis*, and *A. igneus.* Also lost were adults, larvae, and embryos of *Rhinoderma rufum*, the sister species of *Rhinoderma darwinii* (Marcela Vidal, pers. comm., 3 June 2019*). Rhinoderma rufum* has not been seen in the wild for many years and may be extinct (IUCN SSC Amphibian Specialist Group 2015), although we note that two frog species also thought to be extinct, the "hula" frog from Israel, *Latonia nigriventer,* (Biton *et al.* 2013), and an Australian species, *Litoria lorica* (Puschendorf *et al.* 2011), have both been "rediscovered" recently.

CROATIA: SPLIT NATURAL HISTORY MUSEUM AND ZOO GARDEN, SPLIT

Founded on 10 March 1924 as the City Natural History Museum, the zoo was added in 1926. The Split Museum was neglected during the Second World War. From April 1941 to September 1943, the City of Split was occupied by Italian military forces and, from September 1943 to 1944, they were replaced by German military forces. Prior to the departure of the German forces, the museum was bombed by allied forces, resulting in holes in the roof of display areas. Some specimens were destroyed, but others had been transferred to the Bishop's Palace. Loss was also the result of theft and misplacement during relocation of the collection on no fewer than five occasions. All relevant documentation was lost or destroyed (Josip Boban, pers. comm., 28 August 2019).

CROATIA: CROATIAN NATURAL HISTORY MUSEUM, ZAGREB

The National Museum was founded in 1846 and became known by its present name in the following century. The Kingdom of Croatia persisted until 1918, then following the Second World War it was incorporated into what became Socialist Yugoslavia, under the leadership of Marshal Tito. When Tito died in 1980, there was a steady breakup of Yugoslavia until 1991, when part of the country became the Republic of Croatia. The "War of Independence" lasted from 1991 to 1995. During this period, the museum had no professional supervision. Books and specimens (including preserved snakes) were stolen (Josip Boban, pers. comm., 30 August 2019).

CZECH REPUBLIC: GEOLOGICAL INSTITUTE, PRAGUE

Although herpetological specimens have not been lost in the Czech Republic, several significant specimens have been destroyed after their transfer to other institutions (Zbyněk Roček, pers. comm., 18 June 2019). All specimens were fossil frogs.

Rana luschitzana and *Apherion reussi,* from the Lower Oligocene locality of Luzic in northern Bohemia, in the western part of the Czech Republic were described by H. von Meyer (1852), then placed in the private collection of the Count of Lobkowitz in his castle at Bilina. Subsequently, they were donated to the museum in Budapest, where they were destroyed by the Russian invasion during the Hungarian revolution in 1956. The holotype of the Pliocene fossil frog *Pliobatrachus langhae* described by Fejérváry in 1917 was destroyed at the same time.

ENGLAND: HUNTERIAN MUSEUM, ST LINCOLN FIELDS, LONDON

The Hunterian Museum is in the Royal College of Surgeons of England at St. Lincoln Fields in London and is named after John Hunter (1728–1793). He was a gifted surgeon and excelled in other specialties, including biology, physiology, pathology, and natural history. His achievements are remarkable when it is realized that he was one of 10 children and that his father died when he was 10, resulting in Hunter having minimal education. At the age of 17, he was manager of a cabinet-making business. His manual dexterity as a surgeon was attributed to this period of his life when he was engaged in wood carving. He accumulated a collection of over 10,000 natural history and other items and two years after his death the collection was purchased by the government in 1795 for £15,000 and placed in the Royal College of Surgeons' Hunterian Museum.

The route by which the specimens reached the Hunterian Museum is elaborated upon in Whitehead (1969), Kaeppler (1974), and Kaeppler (1979). Two rooms at the College and their contents of approximately 43,000 biological specimens were destroyed in May 1941, during World War II, when the building was hit by a bomb. The type specimen of an Australian frog species, *Pelodryas caerulea* was lost (Tyler & Dobson 1973). The generic placement of this species follows Tyler and Knight (2020: 74), but we note that the Australian Society of Herpetologists in an "expert" listing of names for Australian frog and reptile species published in 2022 uses the generic name *Litoria* (https://static1.squarespace.com/static/5448a9abe4b0ad6dc5e6fe6d/t/62bd01e6bb4f113e9693b54a/1656553963596/ASH+Official+Species+List+30+June+2022+Complete+Version+With+Comments.pdf; accessed 20 November 2022), but Dubois & Fretey (2016) preferred *Ranoidea* as the appropriate generic name for Australian hylid frogs. This is a contentious issue that could have been easily resolved if a series of paratypes had survived World War II at other locations.

Material that escaped destruction in the bombing included Charles Darwin's substantial collection of fossils assembled during the voyage of the Beagle, recently summarized by Lister (2018). Much of the vertebrate material was studied and described by Sir Richard Owen in his early days as curator of the Hunterian Museum and Hunterian Professor. Owen was primarily a paleontologist with his most significant herpetological work being the *History of British Fossil Reptiles* (Owen 1894).

FRANCE: JACQUES-JULIEN HOUTOU DE LABILLARDIÈRE COLLECTION, PARIS

In the late eighteenth century, European nations with colonial aspirations were extremely active. Voyages of exploration were commonplace; one that is particularly well known is the 1791 expedition to the South Pacific by the French naval officers Joseph-Antoine-Raymond de Bruny d'Entrecasteaux and Jean-Michel Huon de Kermadec of the "Recherche" and "Espérance," respectively. Isolated from Europe and, therefore, news of the French revolution, the captains died of disease and the expedition eventually ground to a halt in Java in October 1793. In early 1794 the ship's remaining officers were placed under house arrest and later transferred to prison.

The scientific leader of the expedition was the French naturalist Jacques-Julien Houtou de Labillardière. When he discovered that his collection, packed in 22 cases, including one in which there were two Mason jars of "reptiles, fish, and insects," had ended up in England at the British Museum (reptiles then would have included amphibia), he wrote to Joseph Banks seeking their restitution. Banks was President of the Royal Society at that time. Banks replied in June 1796 outlining the various steps he had taken to achieve that objective, even though the collection was not formally deposited anywhere when confiscated.

This action attracted considerable interest because France and England had been variously at war, and the role played by Banks did not reflect the relationship of the victor to the vanquished: the specimens were "spoils of war". The relationship between Banks and Labillardière and details of their communications eventually leading to the return of material to France are detailed in Duyker (2003). Labillardière's primary interest was botany, with the collection returned to the "Jardin des plantes" in Paris, formerly the Jardin du Roi, which later became the Muséum national d'Histoire naturelle (Duyker 2003: 223). At least some of the animal material, in jars, primarily insects, were said by Banks to be "much damaged" somewhere on their passage from Australia to Java then ultimately via the Cape of Good Hope to London then to Paris. We have no information on the nature or fate of any herpetological material included in this collection described as "a considerable number of dried Lizards and Snakes" (Duyker 2003: 208).

GEORGIA: SIMON JANASHIA MUSEUM OF GEORGIA, TBILISI

Simon Janashia was a Georgian historian. The museum that honors his name began as the Museum of the Caucasian Department of the Russian Imperial Geographic Society, founded on 10 May1852. In 1865 the name was changed to the Caucasian Museum but following Georgia's independence from Russia in 1918, it became the Museum of Georgia the following year. Following the Bolshevik assimilation of the country in 1921, most of the museum collection was exported to Europe for safety and remained there until its repatriation in 1945. The museum's name was changed to include the name of Simon Janashia in 1947.

A military coup in Georgia in 1991–1992 led to damage to the museum, followed by destruction by fire. The main part of the exhibits was dominated by items of archaeological significance (for example, 80,000 coins of local origin).

There was a collection of zoological material, but we have been advised that severe financial constraints mean funds are inadequate to maintain alcohol for type specimens of herpetological material (Natalia Ananjeva, pers. com., 11 August 2019).

GERMANY: NATURAL HISTORY MUSEUM, BERLIN

Berlin University was founded in 1810 and included a zoological museum, which later became the Museum für Naturkunde. The zoological collections are linked to the Leibniz Institute for Evolution and Biodiversity Science.

Of the many distinguished herpetologists associated with the museum, Wilhelm Peters (1815–1883), the director from 1857 to 1883, was by far the most productive. The scope of his studies was almost global with reproduction of his published works in a volume edited by Bauer, Günther & Klipfel (1995) occupying more than 700 pages.

The museum was hit twice by World War II bombing. The west wing was mostly destroyed on 22–23 November1943, while the east wing was destroyed on 3 February 1945. The latter caused the loss of some preserved specimens (giant snakes, turtles, and crocodiles) in the exhibition, but the number is unknown (Frank Tillack, pers. comm., 26 January 2022). Types and other significant specimens that had been transferred to the museum basement and a bank vault survived.

In addition to the specimens lost in the bombing of Berlin, 314 caudates on loan to the museum in Budapest were lost when that museum was destroyed by fire during the Hungarian uprising in 1956. Two separate collections of the Alpine Newt *Ichthyosaura alpestris* were sent in 1956, 139 specimens on 26 July, followed by a further 175 specimens on 3 September (Frank Tillack, pers. comm., 26 January 2022).

GERMANY: THE NATURAL HISTORY MUSEUM OF THE UNIVERSITY OF BONN

Founded in 1818 by the Prussian government, the Natural History Museum of the University of Bonn has a rich history and benefited from contributions by such important herpetologists as Georg August Goldfuss (1782–1848), Franz Hermann Troschel (1810–1882), and Franz Leydig (1821–1908). The museum allegedly suffered from missing curatorship in the 1930's and it was totally destroyed by allied bombing in early 1945. Among the

remarkable specimens lost were the holotypes of *Cophosaurus texanus* Troschel and the giant Cape Verdian skink *Chioninia coctei*, the latter species now considered extinct (Philip Wagner, pers. comm., 21 February 2022; The Reptile Database; accessed 25 June 2022).

GERMANY: STAATLICHES MUSEUMS FÜR TIERKUNDE, DRESDEN

The Dresden Museum was one of the first to be founded in Europe. A further claim to fame was experiencing two major disasters to its collections. Fritz (2002) provided a historical account. The museum is now part of Senckenberg Naturforschende Gesellschaft as a department of the Senckenberg Natural History Collections, Dresden (Türkay *et al.* 2018).

The museum dates to 1560, when the Saxon Elector August 1 founded what was called the Chamber of Arts, which included many natural history items. In 1728 the Saxon Elector and Polish King, August the Strong, moved the natural history collection into a different building, where it remained until it was destroyed by fire during the May 1849 uprisings in Dresden. In the late 1960's the museum received collections from the former zoological museum at Leipzig University, partly assembled by E.F. Poeppig (1798–1868), a portion of whose important herpetological collections are presently housed in the Dresden Museum (Uwe Fritz, pers. comm., 14 February 2022).

In the nineteenth century the museum was extremely active and became one of the most significant in Europe accumulating an extensive collection from the colony of German New Guinea. In the 1880's, zoologist A.B. Meyer was the director, and Meyer (1887), summarizing his collecting activities from 1870 to 1873 in New Guinea, the Celebes (Sulawesi), and the Philippines, listed 192 species of reptiles and amphibians.

Obst (1977) documented the precise losses of herpetological specimens when Dresden was bombed on 13–14 February 1945 reporting that 90% of the museum's herpetological collection was destroyed. Obst also gave details of the holotypes and syntypes of each of the 86 species involved, including material collected and/or described by Benno Wandolleck (14 species), Oskar Boettger (6 species), Franz Werner (16 species), Adolph Bernhard Meyer (31 species), and Johann Gustav Fischer (19 species). The types were diverse. By far the largest number (33 species) was collected in New Guinea. Little material survived the bombing, with the collection decimated from 6,704 to only 98 specimens, among them a few types (Fritz 2002). The surviving type specimens, and material acquired later, is listed, with details, in Fritz (2002) with their current status confirmed by Uwe Fritz (pers. comm., 16 February 2022). This collection includes several paratypes obtained from other German museums, which is a practice we advocate.

GERMANY: ZOOLOGICAL MUSEUM, UNIVERSITY OF HAMBURG

From collections made by Wilhelm Ehrhardt from 1897 until his death in 1936, the zoological museum at the University of Hamburg received 867 herpetological specimens from Brazil, representing no fewer than 95 species (Gutsche *et al.* 2007). The collections in this museum were partly destroyed in July 1943 during the Second World War. Crumly (1984) reported that, hampered by limited funds, it was decided to evacuate only the most valuable items from the collections, and these were transferred to the basement of a brewery. Unfortunately, a bomb was dropped down an air shaft in the brewery and destroyed everything. Fortunately, most of the specimens in alcohol survived, as they were stored separately underground in the metro (Hallerman 2007), but all appropriate documentation was lost.

GERMANY: MUSEUM OF NATURAL HISTORY, MAGDEBURG

The foundation of the natural history museum followed the formation of the local Natural History Club in 1869, leading to the first exhibition of material in 1875. The name changed to the Natural Science Museum in 1893, to the Museum of Natural and Local History from 1905 to 1935, then in 1936 it became the Museum of Natural History and Prehistory; after 1945, this name was changed again to the Museum of Natural History, presumably reflecting the reduced scope of the collections.

One person more than any other was responsible for its herpetological collection. Wilhelm (Willy) Wolterstorff (1864–1943) joined the staff in 1891 and remained until his death. Wolterstorff had numerous overseas contacts. Consequently, he assembled a vast collection of salamanders (Figure 3). At that time, it was probably the largest collection of salamanders in the world. Details of Wolterstorff's contributions were summarized by Bischoff (2001) and Bischoff & Pellmann (2014).

On 16 January 1945, a major air raid by the British RAF led to thousands of members of the public losing their lives and the destruction of the herpetological collection (Figure 3). Fortunately, major floods of the Elbe

River in 2002 and 2013 had no impact on the museum because of its position above the flood line (Bischoff & Pellman 2014).

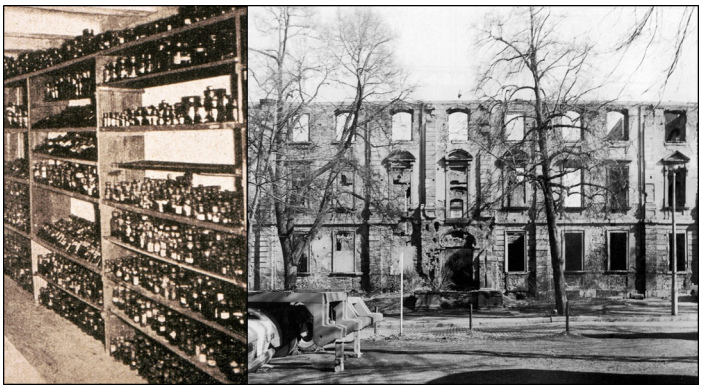

FIGURE 3. View of urodele collection (left) of Wilhelm (Willi) Wolterstorff in the Museum of Natural History, Magdeburg; (left), prior to WW II bombing and (right) the museum building after the bombing. Images courtesy of Wolfgang Bischoff and Wolfgang Böhme.

GERMANY: MUNICH ZOOLOGICAL MUSEUM, MUNICH

The zoological museum at Munich, currently known in English as the Zoological-zootomical collection of the Bavarian Academy of Sciences, was founded in 1811. The first significant collection of herpetological material destined for the museum was assembled in Brazil by Johann Baptiste Ritter von Spix and a botanist Carl Friedrich Philipp Martius from 1817 to 1820. Over a century later, the collection suffered extensive damage from allied bombing in April 1944, when parts of the herpetological collections were destroyed. Hoogmoed & Gruber (1983) prepared a catalogue of extant and lost type specimens described by Spix and his colleague Wagler, later supplemented by Hoogmoed (1986), Glaw & Franzen (2006), Franzen & Glaw (2007) and Böhme (2014) with the latter containing several "neotype" designations replacing type material lost in World War II.

The museum has a historical focus on the herpetofauna of South America, with collections provided by a variety of sources from Chile, Colombia, Argentina, Venezuela, Brazil, Paraguay, and Bolivia (Franzen & Glaw, 2016). For the last 25 years, however, the focus of the collection and the research has shifted to Madagascar. In honor of Johann Spix, the museum's scientific publication is named *Spixiana*. Glaw & Fuchs (2001) provided a history of herpetology at Munich, including information on lost type material (available at https://www.zsm.mwn.de/geschichte/geschichte-herpetologie/?lang=en, Bavarian State Collection of Zoology; accessed 23 September 2022).

GERMANY: STATE MUSEUM OF NATURAL HISTORY, STUTTGART

The Stuttgart Museum was founded in the seventeeth century. The first material stored there, however, was collected around 1600. The museum became significant herpetologically with the collections of Carl Ferdinand Heinrich Ludwig (1784–1847) and Duke Paul Wilhelm von Württemberg (1797–1860). The first curator of zoological collections was C.F. Kielmeyer, appointed in 1790, with the first Curator of Herpetology, H. Wermuth, appointed in 1962 (Schlüter & Hallermann (1997).

Part of the herpetological collection was destroyed by bombing in September 1944. Schlüter & Hallermann (1997) reported at least 12 reptile type specimens were destroyed. All were reptiles described by Fischer in four papers published between 1879 and 1885. Curiously, although Schlüter & Hallermann (1997: 1) wrote "at least 12 type specimens," they provided details on 19 specimens, i.e., six holotypes and 13 syntypes, representing 12 species. Of equal significance was the loss of the original museum catalogue, limiting the capacity to check current holdings for loss of any specific specimens and whether, for example, any were lost before World War II.

GERMANY: NATURAL HISTORY MUSEUM OF WIESBADEN

The Natural History Museum of Wiesbaden was founded in 1829 in the Palace of the Crown Prince. Köhler & Gůsten (2007) reported that a portion of the collection was destroyed during the Second World War: "As a fate of history, most of the alcohol-preserved type specimens survived World War II in Wiesbaden, as they remained in

the public exhibition, whereas the rest of the alcohol collection was moved to a supposedly save [sic] place where it was destroyed." From the specimens documented by Köhler & Gùsten (2007), at least eight herpetological types were lost.

The findings for Germany are continually being updated, including the origin and identity of the von Borcke collection of amphibians and reptiles, in the Museum für Naturkunde in Berlin, which highlights the importance of, for example, Seba's second collection of specimens (Bauer & Günther 2013). The need for further investigation concerning Germany's Zoological Collections, given their importance as both historical and contemporary scientific resource material, was emphasized by Kaiser *et al.* (2018).

The Second World War resulted in major disruption to German twentieth century herpetological collections, more so than in other European countries. Taylor (1969) and Frost (1985) documented the destruction of many types in such collections. This is not the case, however, for most of the collection by Bloch, which was obtained by the Berlin Museum in 1810, and is still extant (Bauer 1999).

GERMANY: THEODOR-BOVERI-INSTITUTE BIOCENTER, JULIUS-MAXIMILANS UNIVERSITY OF WÜRZBURG, WÜRZBURG

Bonavita Blanck (1740–1827), a member of the Order of Friars Minor and Professor of Science at Würzburg University was responsible for assembling a collection that bore his name, i.e., Blancksche Naturalienkabinett. This material and subsequent collections were destroyed by WW II bombing on 16 March 1945. The collections included specimens collected by Pieter Bleeker (1819–1878), an ichthyologist who described almost 2,000 fish species and a few herpetological species. Further material in the Fränkisches Museum für Naturkunde was housed initially in the Würzburg Residence Castle. Currently, a new collection of vertebrates held by the Museum is used solely for teaching purposes.

HUNGARY: NATURAL HISTORY MUSEUM, BUDAPEST

Few institutions have suffered so frequently and so extensively as the Hungarian Natural History Museum, founded as the National Museum in 1802. In 1809 the collections were temporarily evacuated to save them from the advancing Napoleonic forces. In 1838 almost the entire collection was inundated in the great flood of the Danube River at Pest. In 1870, the natural history department was set up, and in 1930 the Natural History Museum became independent from the National Museum. In January 1945, Budapest was under siege, when shells hit the main museum building, heavily damaging the mineral and paleontological collections.

On 24 October 1956, Russian forces invaded Hungary and, without warning, bombarded Budapest. The collections and exhibitions of the main museum building and the nearby three-story building in Baross Street, which housed the Department of Zoology, were destroyed. The fish, amphibian, and reptile specimens stored in an estimated 20,000 liters of alcohol caught fire and the entire collection was destroyed within minutes.

Boros (1957) provided a detailed report describing the losses department by department. With the loss of records, the number of specimens involved is uncertain, but approaches 40,000. Also lost was a series of 314 caudate specimens on loan from the Berlin Museum and another 150 from the University of Bucharest.

Among the known collections was one of 157 specimens obtained by Lewis (Lajos) Biró in German New Guinea, reported by Méhely (1898). By 1902, the herpetological material in the collection contained 5,066 specimens representing 973 species, including many type specimens (Korsós 2008). Since 1956, a new herpetological collection has developed, based on extensive field collections, and donations of surplus material by the personnel of many fellow institutions. Mainly due to the tireless work of general director István Boros and herpetology curator Olivér György Dely, the collection reached 16,000 specimens (Korsós 2005), but amounts to around 20,000 today.

INDIA: ZOOLOGICAL SURVEY OF INDIA, 1942–1945, CALCUTTA

At the outbreak of war with Japan in December 1941, it was decided for the safety of the collection that it be transferred from its headquarters in the Indian Museum at Calcutta to the Duyker Kaiser's Castle at Benares. The Kaiser's Castle was the private property of His Excellency Supradipta Manyabara Commanding General Sir Kaiser Shamstere Jung Bahadur Rana.

The buildings holding the collection were on the banks of the Varuna River, a tributary of the Ganges. The first known flood of the Varuna was a major event in September 1943.

Chopra (1946: 349) gave an account of the impact of the flood on the herpetological collection, as follows:

"The collections of this Section were stored in two rooms above ground and a small part in one of the cellars. In the smaller room, on account of the subsidence of the floor, a rack, containing Amphibia, was overturned, but fortunately damage to the collection was only slight. In the other room in which lizards and most of the snakes were kept, the racks held fast and the damage there was slight. The chelonians and the larger snakes were stored in the cellar and damage to these was heavy because of their long immersion in water. Fortunately, very few types in this section were lost.

Chopra (1946: 350) noted that "in the Order Testudines, the families Emydidae and Trionychidae and in the Order Squamata, Sub-Order Serpentes, the family Uropeltidae have been seriously damaged. The Agamidae, Scincidae, and Lacertidae in the Sub-Order Sauria and the Colubridae in the Serpentes have also been somewhat damaged. The amphibians have practically escaped damage." Finally, Chopra (1946: 350) stated that "the total damage to the collections of the Reptilia and Amphibia Section is very roughly estimated at under 20%".

INDIA: NATIONAL MUSEUM OF NATURAL HISTORY, NEW DELHI

The study of the herpetofauna of India antedated the establishment of a national museum (Das 2004). The colonization of India by the British followed the creation of the East India Company (1600–1858), with a charter from Queen Elizabeth I to establish trade with Great Britain. Consequently, many collections were sent to the then British Museum (Natural History), where they were reported by Günther (1858, 1864) and later by Boulenger (1890) and others. This is a hugely complex topic, as material also went to India House, the British East India Company's quarters in London, and from there went to the British Museum, often much later.

Following independence in 1947, the Indian museum undertaking the most significant research was the Zoological Survey of India, headquartered in Calcutta with over a dozen stations throughout the country. Other centers of activity post-independence included the Madras Government Museum, where, in 1888, Edgar Thurston, the Superintendent of what was then called the Government Central Museum, produced a catalogue of the amphibians of Southern India. This provided a stimulus for subsequent studies and was updated by Sathiamurti (1967).

In 1972, to celebrate 25 years since India's independence, Indira Gandhi, then Prime Minister, supported a proposal for the creation of a national natural history museum as an appropriate means of celebrating the event. The proposal was adopted, and the museum opened in 1978.

The building was allowed to fall into disrepair and, the building, and all collections were destroyed by fire on 26 April 2016. The extent and speed of the conflagration was largely attributed to the fire control sprinkler system being inoperative (Dutta 1997; Indraneil Das, pers. comm., 22 February 2022).

Dutta (1997) reported that the National Museum held holotypes and paratypes of two species of the frog genus *Nyctibatrachus* Boulenger, i.e., *N. aliciae* Inger *et al*. (1984) (the holotype and 13 uncatalogued paratypes), and *N. minor* Inger *et al.* (1984) (the holotype and 14 uncatalogued paratypes). Among the reptile types lost were the primary types of *Mabuya clivicola* Inger, Shaffer, Koshy & Bakde (1984; current name *Eutropis clivicola*) and of *Cnemaspis nairi* Inger, Marx & Koshy (1984). Dutta (1997) reported that none of the types of 20 Indian frog species or subspecies described by Rao (1937) can be located; their taxonomic status is uncertain but any type material may have been lost in these various museum disasters in India. Evidently, the neglect of the building extended to the collections; after 13 years from deposition, the types had not been catalogued individually. Fortunately, 50% of the type series of the *Nyctibatrachus* species were deposited in the Field Museum of Natural History in Chicago, where they survive today (Dutta 1997; Indraneil Das, pers. comm., 22 February 2022).

ITALY: MUSEO CIVICO DI STORIA NATURALE, GENOA

The museum was founded in Genoa in 1867 following a proposal by Marquis Giacomo Doria (1840–1918), who became its first director. Doria had a broad interest in natural history, particularly entomology and herpetology. He collaborated with W.C.H. Peters of Germany and was aided by G.A. Boulenger of London in the identification of specimens collected in New Guinea by Luigi D'Albertis (1841–1901).

The collecting activities of D'Albertis and the involvement of George Albert Boulenger in the identification of the material collected resulted in the accumulation of type specimens of 159 species and subspecies of reptiles and 52 species and one subspecies of amphibians. The well-known collaboration of W.C.H. Peters and G. Doria was also a source of identification expertise.

A brief summary attached to the reptile collection catalogue states that the geographic focus of the museum collection was the Oriental and Ethiopian biogeographic regions. There are numerous exceptions from the

Neotropical and Australasian regions, including the rarely visited Aru Islands in the shallow sea between Australia and New Guinea and Somerset on the tip of the Cape York Peninsula of Queensland, Australia (Giuliano Doria, pers. comm., 6 September 2019).

Following heavy rain on 7 – 8 October 1970, a major flood developed on the River Bisagno in Genoa, leading to the loss of eleven type specimens of six species of reptiles, recorded in pencil by Lilia Capocaccia in a reprint of the catalogue (Capocaccia & Poggi 1982), as follows: *Emydura albertisii* Boulenger, 1888 – 2 syntypes; *Agama doriae* Boulenger, 1885 – 5 syntypes; *Podarcis depressa* Camerano, 1877 – 1 syntype; *Lygosoma sphenopsiforme* Boulenger, 1909 – holotype; *Chalcides ocellatus* Var. *ragazzi* Boulenger, 1890 – holotype; and *Rhampholeon robecchii* Boulenger, 1892 – holotype.

Capocaccia did not record any losses of Amphibia. The director, Giuliano Doria, advised us that he has been unable to locate any relevant internal documentation. Subsequent floods in 1992 and 2014 also entered the museum but had no impact on the herpetology collection (Giuliano Doria, pers. comm., 6 September 2019).

ITALY: CIVIC MUSEUM OF NATURAL HISTORY, MILAN

The Milan Natural History Museum was founded in 1838. Apparently, it was the only Italian natural history institution destroyed during the Second World War. The museum was hit and incinerated on the night of August 13–14, 1943, following an Anglo-American air force raid, which dropped multiple incendiary bombs.

Parisi (1944) documented the loss of both invertebrate and vertebrate specimens and stated that 3,640 amphibians and reptiles stored in alcohol were lost in the inferno. Blackburn & Scali (2014) reported, however, that many type specimens indicated to have been destroyed were in fact saved and the surviving collection of amphibian types includes salamanders and 17 frog species. Although reptiles were not discussed, but we understand (based on an anonymous reviewer's comment) that many of the reptile types were also saved.

JAPAN: RIKUZENTAKATA CITY MUSEUM, RIKUZENTAKATA

The Rikuzentakata City Museum, located in Rikuzentakata, Japan, was founded in 1959 and in 1979 was moved to a facility near the ocean (Kumagai 2014). The museum staff had accumulated a small collection of amphibians and reptiles when the museum was struck by the "Great East Japan Earthquake and Tsunami," otherwise known as the "2011 Earthquake" on 11 March 2011. The earthquake was the strongest to ever hit Japan and the resulting tsunami caused extensive damage to the city of Rikuzentakata and the City Museum (Figure 4). The museum contained about 230,000 artifacts of archeological, folkloric, historical, biological, and geological significance (Kumagai 2014). The entire staff was killed by the tsunami. A salvage operation was undertaken by staff of other museums in Iwate Prefecture about one month later. They recovered three bottles of salamanders, two bottles of snakes, and a few stuffed specimens of reptiles. (Suzuki Mahoro, pers. comm., 8 July 2019). After the earthquake and subsequent tsunami, specimens were transferred from damaged museums to more than 40 other museums and research institutions at remote sites all over Japan (Sakuma *et al.* 2015). No records were found to indicate how much material was lost. There are numerous other small museums in East Japan, but we have been unable to determine if any of them housed herpetological material prior to the tsunami (Suzuki Mahoro, pers. comm., 7 February 2022). The importance of the salvaging efforts to museum collections, such as those undertaken after the 2011 tsunami in Japan, alongside ecosystem-based disaster risk reduction to avert future natural disasters cannot be overstated (Hideo & Suzuki 2011; Nishida *et al.* 2017; Suzuki & Makoto 2017). Comparable tsunami impacts occurred in 2004, affecting in particular Aceh in Indonesia, but with impacts around the Indian Ocean (https://en.wikipedia.org/wiki/2004_Indian_Ocean_earthquake_and_tsunami; accessed 26 September 2022).

LIBYA: AS-SARAY AL-HAMRA MUSEUMS, TRIPOLI

Following a period as part of the Turkish Ottoman Empire, the country was conquered by Italy in 1911 and was named Libya from 1934. The original name of the Assaray Al-Hamra Museums (plural), Tripoli, followed that of Italian institutions such as Museo Libico di Storia Naturale, founded in 1869. Civil war in 2011 led to looting and destruction but Bauer *et al.* (2017) did not report any lost type material in their extensive report, "Atlas of the Reptiles of Libya." However, this was not the focus of that publication; it listed reptile and amphibian species recorded in Libya and their known geographic occurrences rather than any systematic history or location or history of type specimens for these various taxa.

FIGURE 4. Tsunami damage that occurred on 11 March 2011, to storage room on ground floor of Rikuzentakata City Museum, Rikuzentakata, Japan. Courtesy of Rikuzentakata City Museum.

MALAYSIA: FEDERATED MALAY STATES MUSEUM, KUALA LUMPUR

The main building of the Federated Malay States Museum was completed in 1907. Its staff collected throughout the Malay Peninsula and published in the in-house "*Federated Malay States Museums Journal,*" which issued 19 volumes between 1905 and 1939. A misdirected load of bombs from an American B29 bomber on 10 March 1945 led to the near total destruction of the collection (Das & Yaakob 2007). This was the country's sole national museum emphasizing biological diversity, and no equivalent replacement has materialized since 1945. More recent herpetological types and other important collections are, however, in the holdings of various state museums and those maintained by local universities (Indraneil Das, pers. comm., 24 February 2022).

MEXICO: MUSEO DE ZOOLOGÍA, MEXICO CITY

During our inquiries around the world about earthquake damage, various reports were made of severe damage to downtown Mexico City by an earthquake in September 1986. The earthquake was severe and measured 8.1 on the Richter scale. We were assured by Prof. Dr. Oscar A. Flores-Villela (pers. comm., 5 June 2019), however, that their natural history collection suffered no damage, and no herpetological specimens were lost. We include this example as it may provide details of how to design or locate museum buildings to minimize damage in earthquake prone localities such as Managua, Nicaragua. For example, see https://en.wikipedia.org/wiki/1985_Mexico_City_earthquake (accessed 23 September 2022) for a discussion of resonance effects, building height and risk of earthquake damage.

NETHERLANDS: PRINCE OF ORANGE-NASSAU OF THE NETHERLANDS (STADHOLDER) COLLECTIONS, THE HAGUE

Albertus Seba (1665–1736), a wealthy Dutch pharmacist, assembled two collections of natural history specimens, based on material collected throughout the world. The first was purchased by the Czar of Russia. When Seba died, his second collection was divided and sold to several institutions and to the Prince of Orange-Nassau of The Netherlands, who maintained a private museum of 30,000 specimens and a menagerie that included two elephants (Pieters 1980).

In 1794 the French revolutionary army invaded and conquered The Netherlands, the final battle taking place on 20 January 1795. The Stadholder William V of Holland fled to England without his collection. Scientists were seconded to the French army, and they selected and arranged the packing of 95 boxes of confiscated material from the Stadholder's collection for transfer to Paris. According to correspondence by the French Chief Botanist André Thouin (1747–1824) (Thireau *et al.* 1998), the ship departed on 19 April 1795, and the contents, including amphibians and reptiles, were transported to the Museum National d'Histoire Naturelle in Paris. The museum had been established on 10 June 1793, in the former Jardin du Roi and had room for considerable expansion (Lipkowitz 2014).

The word Orange refers to the small principality in the south of France held by the family from the eighth century until 1713. After 1530, the German county of Nassau was added to it. The Stadholder was a hereditary

leader until the position was abolished in 1795. The Stadholder's natural history collection was enlarged between 1756 and 1796, thanks to purchases that the cabinet's director, Aernout Vosmaer (1720–1799) made at auction and to shipments of natural-history objects from the Dutch colonies (Pieters 1980; Lipkowitz 2014).

NEW GUINEA: DEPARTMENT OF BIOLOGY, UNIVERSITY OF PAPUA NEW GUINEA, PORT MORESBY

The collection of amphibians and reptiles at the Department of Biology is extensive and includes type specimens of 77 species (Shea & Kraus 2007). These authors undertook several searches of the collections and were unable to locate 88 type specimens representing 14 genera and 28 species. The collection dates from 1967, when J.I. Menzies was appointed curator. He remained until 1977 and returned in 1988, before retiring in 1999. Hopefully, at least some of the missing or indeterminate specimens will eventually be located intact, and a permanent solution found for the care of this valuable collection.

NICARAGUA: NATIONAL MUSEUM, MANAGUA

There are two accounts of damage to the herpetological collection at the National Museum of Nicaragua, the first in 1931 and a second in December 1972. On both occasions, the herpetology collection was destroyed due to fires resulting from earthquake impacts.

There is a paucity of information regarding the earthquake in 1931, but Sunyer (pers. comm., 20 March 2020) and Sunyer (2009) provided a detailed account of the herpetological collections received from various expeditions, including the US Navy. Managua suffered almost total destruction in major quakes followed by fire in 1931 and again in 1972 (J. Sunyer, pers.comm., 19 October 2022) but Nicaragua has experienced twelve significant quakes since 1931 (https://en.wikipedia.org/wiki/List_of_earthquakes_in_Nicaragua; accessed 9 September 2022). The current status of any type material that was held in museums in Managua as a consequence of this history of earthquake and fire is not clear but J. Sunyer stated that both major earthquakes in 1931 and 1972 led to fires that destroyed the herpetological collection in the National Museum so any types held there were certainly lost.

PHILIPPINES: NATIONAL MUSEUM OF THE PHILIPPINES, MANILLA

The National Museum of the Philippines is divided into several museums; the National Museum of Natural History is one. The National Museum was founded in 1901 as the Insular Museum of Ethnology, Natural History, and Commerce. In 1903 it became the Bureau of Ethological Survey and the following year it changed to the Philippines Museum. In 1933 it was divided and herpetology, in the Division of Ethology, joined the Bureau of Science.

The Japanese occupation during World War II led to the loss of part of the collection when the liberating U.S. army shelled the Old Legislative Building where the collection was housed. Among the specimens destroyed were three species reported by van Tuijl (1995), including the types of the toad *Bufo mcgregori* Taylor from Mindanao Island, the lizard *Brachymeles vermis* Taylor from the Sulu Archipelago, and the snake *Naja naja philippinensis* Taylor from Luzon Island. The holotype of the toad *Bufo mcgregori*, (now placed in the genus *Ansonia*), is indicated at the Amphibian Species of the World website (www.amphibianspeciesoftheworld.com/; accessed 24 January 2022) to have been "reported in error as destroyed in WWII by van Tuijl (1995)" but is actually present in the herpetological collection of the California Academy of Sciences as CAS 61839. The holotype of the scincid lizard *Brachymeles vermis* is confirmed as lost and probably destroyed, as noted, at the Reptile Database website (https://reptile-database.reptarium.cz/; accessed 25 January 2022); and the holotype of the elapid snake *Naja naja philippinensis*, a subspecies now elevated to species status as *Naja philippinensis*, is lost or destroyed (Reptile Database website, http://www.reptile-database.org/; accessed 23 September 2022) but the cause of these latter losses is unknown.

POLAND: ZOOLOGY MUSEUM AND INSTITUTE, UNIVERSITY OF WROCLAW, WROCLAW

The University of Wroclaw was established in 1811 and the Museum of Zoology in 1814. A separate building for the natural history collections was constructed in 1904. Late in World War II (there is no specific date because the area was evacuated, but it was in the first half of 1945), the building was bombed and much of the herpetological collection, including all registers, was destroyed. The number and identity of specimens lost is not known (T. Stawarczyk, pers. comm., 16 September, 2019).

PORTUGAL: NATIONAL MUSEUM OF NATURAL HISTORY AND SCIENCE, LISBON

The National Museum has existed under several names since it was founded in 1768. It commenced as the Royal Natural History Museum. In 1858 the collections were transferred to the Polytechnic School, and three years later, it was named the National Museum of Lisbon.

When the University of Lisbon was founded in 1911, the museum became formally associated with the University Faculty of Science. The association with the University remains to this day, although its link is now directly to the University Rector and not to the faculty.

On 18 March 1978, the herpetological collection was almost completely destroyed by fire. Fighting the fire was hindered because the Fire Brigade water tanker was too large to pass through the museum gates. Among thousands of specimens, only five individuals survived, because they were on loan elsewhere. Included among those destroyed were type specimens of species from Portugal, Africa (particularly the former colonies of Angola and Sao Tomé e Principe), Australia, and Asia. The African material was reported by Crespo (1971, 1972) and Perret (1976), who both documented the Portuguese material, listing 833 reptiles and 1,418 amphibians. Ceriaco *et al.* (2014) reported that some of the type specimens originally located at Lisbon were transferred to the Natural History Museum of Porto University.

The Curator of Herpetology, with a combined appointment at the universities of Lisbon and Porto (Luis M.P. Ceriaco, pers. comm, 22 January 2019), advised us that, currently, the amphibians and reptiles at the three main Portuguese museums (Lisbon, Porto and Coimbra) total fewer than 12,500 specimens, of which 11,000 are at Lisbon.

ROMANIA: MUSEUM OF NATURAL SCIENCE, BACAU

We do not have details of collections held in Romania, but Frank Tillack (pers. comm., 25 February 2020) advised us that a series of 155 specimens of the Fire-bellied Toad *Bombina bombina* sent on loan on 20 January 1969 from the Berlin Museum were destroyed by an earthquake on 4 March 1977.

ROMANIA: UNIVERSITY OF BUCHAREST, BUCHAREST

The University of Bucharest has had a disrupted, turbulent history where political unrest has been the norm, rather than a rare event. The Princely Academy of Saint Sava was founded in 1694 by Constantin Brâncoveanu, the ruler of Wallachia. In 1861 Wallachia united with Moldavia to form Romania. The educational ambit of the Academy was progressively increased by the addition of more faculties until the present university was founded in 1864. During the Second World War, the university was bombed by German air forces, but we have no specific information on the fate of collections.

RUSSIA: ZOOLOGICAL INSTITUTE, ST PETERSBURG

The wealthy Dutch pharmacist and businessman Albertus Seba (1665–1736) assembled one of the greatest natural history cabinets of his time. In 1717 he parted with his first collection, selling it to Czar Peter the Great of Russia (Engel 1961). The inventory from the first collection sold to the czar included 170 specimens of amphibians and reptiles.

Unfortunately, the main part of this first collection of Seba was destroyed due to improper storage (Milto & Barabanov 2011), however, a few reptile specimens still exist today (Catalogus 1742; Strauch 1889). What remains of the collection, which formed the basis of Peter's Kunstkamer, survived and is housed in the Zoological Institute of Russian Academy of Sciences (Juriev 1981).

Seba amassed a substantial second collection, evidenced in his illustrated four-volume work, the Thesaurus (Seba, 1734–1765). This collection was sold in 1752, 16 years after his passing (Anonymous 1752). A large portion was dispersed to national and royal natural history museums across Europe and parts of the collection were purchased by both natural history and private collectors.

Fortuitously, material from this second sale exists to date in the collections of the following institutions: the Zoological Institute of the Russian Academy of Sciences in St. Petersburg, the Zoological Museum in Amsterdam, the Natural History Museum (formerly British Museum of Natural History) in London, Naturalis, the Nationaal Natuurhistorisch Museum (formerly Rijksmuseum van Natuurlijke Historie) in Leiden, the Muséum National d'Histoire Naturelle in Paris, and others (Boeseman 1970; Juriev 1981; Adler 1989; Thireau *et al.* 1998). Engel (1961) and Boeseman (1970) documented the dissemination of Seba's second collection; however, there are no records of the movement of the collection to Poland.

Daszkiewicz & Bauer (2006) confirmed that part of Seba's collection, which included herpetological specimens, was in the natural history cabinet of Princess Anna Jablonowska (1728–1800), presumably in Poland, during the late eighteenth century. Specimens that originated from the sale of Seba's cabinet on 11 April 1752, were probably obtained indirectly, via a Dutch natural history retailer at an auction on behalf of Princess Anna Jablonowska, aged 24 at the time. Upon her death, Jablonowska's heirs, in debt, parted with her natural history cabinet, which was sold to Czar Alexander I.

The scientists W. Siewiergin and A. Sewastionow from St. Petersburg, along with a French curator, Richard, were required to organize 101 large packages for shipment in Siemiatycze, over a six-week period. Siewiergin noted that the shipment contained "many amphibians and reptiles including vipers" (Wójcik 1970, cited in Daszkiewicz & Bauer 2006: 18).

The collection left Siemiatycze on 15 April 1802, although the czar offered the collection to the University of Moscow, and a part of the collection was dispatched to St. Petersburg in 1875. During the Napoleonic wars, (1803–1815), much of the collection is reported to have been destroyed (Wójcik 1987).

UKRAINE: ZOOLOGICAL MUSEUM, UNIVERSITY OF KIEV, KIEV

The first Museum of Natural History established in the Ukraine was at Kiev in 1868. The revolution in 1917 led to museums being considered of no value. Consequently, some were destroyed. Major changes took place in June 1930, when all museums became institutions charged with promoting communist ideology and suffered continual Bolshevik criticism. The person appointed "Enlightenment Chief Executive" approved a new ordinance requiring all museums to be reorganized with the objective of popularizing the ideals of the Communist Party.

During World War II, numerous provincial museums were destroyed totally, but we do not know if any of them held herpetological collections. They included the Bakhmut County Museum and the Artemivsky District Museum, as well as museums in the cities of Staling Voro, Shilovgrad, Kostyanivka, Sviatogorsk, and Starobilsk.

The Ukraine has had many museums. The Nikolay N. Sczerbak Zoological Museum in the National Museum of Natural History at the National Academy of Sciences of Ukraine did feature displays of amphibians and reptiles (http://museumkiev.org/zoologyeng.html/; accessed 6 October 2022). It is premature to discuss impacts on museums resulting from the Russian invasion of Ukraine in 2022.

USA: CALIFORNIA ACADEMY OF SCIENCES, SAN FRANCISCO

Founded in 1853, the California Academy of Sciences functions as a natural history museum and research institution. The herpetological collection developed significantly under the curatorship of John Van Denburgh, who joined the staff as a student in 1895, left for a period to study medicine, then returned as curator and remained until his death on 24 October 1924 (Slevin & Leviton 1956).

On 18 April 1906, San Francisco was devastated by a major earthquake with subsequent fires throughout the city fed by gas from ruptured gas lines used for lighting. Estimates suggest that 3,000 people died in the holocaust. The Academy was destroyed (Figure 5), and Van Denburgh was able to save only 13 of the 8,100 specimens in the collection and it is said that he did so at great personal risk. After the use of temporary accommodation, the Academy was moved to its present site in Golden Gate Park in 1915 and was completely rebuilt in 2008 (Slevin & Leviton 1956).

Slevin & Leviton (1956) provided details of the early staffing of the Department of Herpetology and listed the names of the specimens rescued by Van Denburgh. Prior to the fire, there were 15 holotypes in the collection; of these, five were destroyed.

Synthesis

A total of 57 collections of preserved herpetological specimens in museums and institutions in 30 countries have experienced damage or loss following a catastrophic event. Losses are spread globally: Africa, Asia, Australia, Europe, North America, and South America. The time span of these calamities ranges from 1716 to 2021, a 305-year period. The damaging events were: cyclone (1); fire (8); earthquake (9); flood (3); other, which includes improper storage, neglect, lost, or missing (4); theft (6); tsunami (1); war (other), which includes civil war, coup, inter-country conflict, and revolution (8); and, the impact of bombing or shelling during the Second World War, that affected

collections in 17 cities in Croatia, England, Germany, Italy, Malaysia, Philippines, Poland, and Romania. Large numbers of type specimens were destroyed in those incidents.

Eight of 40 catastrophic events negatively affecting herpetological collections were fires, focusing on the need for museums to ensure that fire detection and suppression capacities are always functional. Protection against the proximate cause of many other disasters, e.g., earthquake, flooding, or other conflicts, are more problematic, given the inherent unpredictability and potential magnitude of these events. Many museums or institutions are also faced with economic challenges that affect their ability to protect their collections.

FIGURE 5. Views of the California Academy of Sciences building, including, (left), before fire and (right), after fire in 1906. Courtesy of the California Academy of Sciences Library.

Discussion

We have documented major calamities affecting museum collections across the globe, including cyclone (1); tsunami (1); neglect (1); earthquake (5, 3 of 5 associated with fire); fires (5); floods (3); thefts (2); World War II (17); other wars (3); and economic problems (3). We have focused on impacts on herpetological collections. We have highlighted the diversity, frequency, and severity of these events, hoping to create an attitude in which some members of a type series are dispersed among several institutions globally when new species are described. The devastating impacts of the Second World War across Europe and England emphasize the risks that can occur with multiple collections affected within several countries. Major wars in Korea, Vietnam, Afghanistan, Iraq, the ongoing conflict in Israel and Palestine, and most recently in 2022 in Ukraine, are reminders that conflict is an ongoing event and museums will always be at risk.

Protection against natural disasters is equally problematic; cyclones, tsunamis, earthquakes are all difficult to predict in advance, except broadly and our surmise is that none were considered in the design or location of any major museums. However, earthquakes and cyclones can both have major impacts well outside known or commonly anticipated risk zones: Newcastle, Australia was heavily damaged by earthquake in 1989 (Rynn, Brennan, Hughes, Pedersen and Stuart 1992) in an area generally considered a very low earthquake risk (despite a long history of low-level seismic activity in the region). Cyclone Alby caused major power blackouts in Western Australia's capital city, Perth and its metropolitan area and extensive damage and fires in south-western Australia in 1978 – again this is well outside normal risk areas for cyclones that usually develop in the Indian Ocean and cross onto land several hundred kilometers north of Perth (Hetzel, Janeković, Pattriaratchi & Wijeratne 2015).

The solution is simple; where possible, spread type material, preferably globally, but at least nationally to minimize the risk of loss of a whole type series in one museum disaster. When new taxa are described, whole specimens could also be complemented by high resolution images, DNA barcodes, and other metrics that now commonly underlie the descriptions of new species and other systematic decisions, with many of these new data in formats that can be mirrored at multiple sites, minimizing the chances of losing all of the information in future disasters.

The flammability of liquid preservatives is a major risk. Herpetologists at most institutions favor the use of 70% alcohol. A concentration of 65% is equally satisfactory for amphibians, and the 5% reduction is economically advantageous when vast quantities are being used. The only popular substitute for alcohol is the non-flammable formalin, a 37% solution of formaldehyde. Formalin has the disadvantages of an unpleasant smell, requires the use of an appropriate face mask, gloves are required to prevent peripheral skin damage, and it is a known carcinogen (Swenberg *et al*. 2013; La Torre *et al*. 2021). Formalin also degrades DNA, with DNA now the basis of many systematic and biogeographic studies.

Suarez & Tsutsui (2004: 66) noted that "biological collections make innumerable contributions to science and society in areas as divergent as homeland security, public health and safety, monitoring of environmental change, and traditional taxonomy and systematics." Following a major earthquake and tsunami in Japan in March 2011, the International Union of Biological Sciences (IUBS) devoted an issue of its News Magazine, *Biology International,* to a series of papers describing activities that were undertaken in museums following the disaster. Under the heading "Disaster and Biodiversity," the various reports comprised Special Issue 36 published online on 31 July 2017 (https://iubs.org/publications/scientific-journal-biology-international/biology-international-special-issues/; accessed 25 October 2022). In addition to providing a description of the effects of the earthquake and subsequent tsunami, the 17 chapters provide a guidebook for the actions needed to prepare for future, comparable catastrophes but also offer lessons for almost any major disaster type.

Gutiérez & Lattke (2016) drew attention to a further category of catastrophe of risk for museum collections, i.e., chronic neglect. Their concern was based on their experience at the Museo de la Estación Biológica de Rancho Grande, located in Caracas, Venezuela. This natural history museum experienced major staff shortages because the country was in an economic crisis. Staff vacancies were not filled. The museum had six research staff and five technicians in 2006, but this number declined to only two by 2016, leading Gutiérez & Lattke (2016: 710) to state "The Venezuelan government must take immediate action to hire qualified personnel and provide them with resources to adequately maintain the material housed in these collections before irreversible damage commences." Relocation of type material is not a solution; our plethora of examples of loss indicate an inability to predict disaster risk. More importantly, relocation imposes both costs and obligations on recipient collections and potential uncertainty about where material is currently held. The only realistic solution is to ensure that in future species description the type material is dispersed as extensively as possible, in the event that a sufficiently extensive set of type specimens is available. This must become an important element of the review and editorial processes when new taxon descriptions are submitted, it must be embedded in the training of taxonomists, and demanded by museum curators when accepting type specimens that underlie the descriptions of new species.

Conclusions

We assembled information from a range of museums throughout the world that have experienced major calamities, including cyclones, fires, earthquakes, floods, thefts, tsunamis, and wars. These events have resulted in the destruction of museum collections in fifty-seven institutions and thirty countries. We have focused on outlining damage done to the most important specimens in these collections, i.e., the material comprising the types and paratypes of animal taxa that have been formally described. This material is held in collections in perpetuity, for the benefit of specific zoological disciplines, but equally for society in general. These specimens are irreplaceable as the designation of neotypes does not replace the types lost: they only provide a substitute for the originals.

Type specimens are the fundamental heritage of herpetological systematics and, thus, represent the basis for our understanding of herpetofaunal taxonomy. Given that so much damage has been done to portions of this inestimably valuable scientific heritage because of natural disasters and human conflicts, steps should be taken on a global basis to protect the material that remains from the prospect of future damage.

With respect to planning for risk, scientific institutions that house preserved specimens for the purposes of taxonomic and systematic research should guarantee, as much as is humanly possible, that such material will be protected from conceivable damage based on the collection's location and the nature of the collection.

Collection records should be duplicated with a copy stored, and updated, regularly outside of each institution to avoid loss of both specimens and records in a single disaster if these are in traditional "paper" copy. This must also apply to digital records of museum collections, including any relevant images, where the latter is feasible.

Recognizing and minimizing the risk of future disasters is an issue for all taxonomists, not just herpetologists. There is an urgent need to communicate to all levels of government and to the public the importance of museum and herbarium collections for the identification, preservation, and conservation of global biodiversity, as well as the need to support these collections with appropriate resources, both financial and structural, through building design and continuing maintenance that will improve and maintain collection integrity.

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