GENERAL ARTICLE

Drawing New Boundaries

Finding the Origins of Dragons in Carboniferous Plant Fossils

DOROTHYBELLE POLI AND **LISA STONEMAN**

ABSTRACT

Dragons thrive in gaps between and beyond spatial boundaries. Can science help explain their existence? Did humans' investigation of natural phenomena create bits and pieces of dragon lore across cultures? The researchers used a transdisciplinary lens to reveal data unique among extant dragon origin explanations, including fossil evidence and descriptions of Carboniferous-Period plants, dragon folklore descriptions and locations and geographic correlations between the fossils and folklore. The hypothesis is that early humans came across these fossils, constructed meaning for them contextualized by current knowledge of the natural world and created or enhanced dragon lore narratives.

Dragons have been a common thematic focus in art and literature since ancient times (Table 1). Exegeses of dragons, or at least of the origin of the lore that is their essence, have been posed by a number of theorists (see the table in the online supplements) [1–16]. Variations between western and eastern descriptions of dragons' heads may be culturally understood: Western dragons' heads often resemble common, nondescript reptiles', although some appear as hybrid animals (e.g. the French Tarasque). Eastern dragons' heads are a combination of several animals: head of a camel or horse, horns of a stag, eyes of a rabbit or demon, ears of a bull, the neck of a snake. The diversity of conjecture may suggest the origins to be a semantic game with no definitive answer. Are myths and legends born from a single inspiration or from a multiplicity of perspectives? Or is it a combination of these that brings them to life?

Scientific explanations have been used to bring light to the origins of many folktales. The werewolf myth is thought to derive from the genetic hair disorder hypertrichosis [17,18]. Mermaid myths may have emerged from encounters with people suffering from sirenomelia, which causes fused limbs—usually legs [19]. Even the unicorn may be scientifically explained as a mutation producing single antlers or horns on mammals. Is it then plausible that a plant fossil occurring worldwide, covered in beautiful scale patterns, may be an inspiration for dragons?

Humans have always needed to understand the world around them in order to survive. This understanding begins with basic observation. What killed; what helped sustain and heal; what connected people to God? Similar to Aristotelian ideals, these were likely the first natural science categories. Plants provided food, medicine or mind-altering experiences, given knowledge of their properties. Aristotle used observational methods in his taxonomic hierarchy, placing plants at the bottom of his Ladder of Life [20]. As botanical knowledge grew, classification became more elaborate and scientifically accurate. Plants were broken down into trees, shrubs and herbs. Today we categorize species based on evolutionary adaptations in genetics, metabolism, development and ecological habitats. The evolution of categorization reveals the progression of cultural/societal needs.

As this understanding evolved, so did our comprehension of extinct life. Fossils of marine animals were noted as early as the sixth century, but scientific identification did not occur until the eighteenth century. In the interim, people collected and classified findings, trying to comprehend how these strata were formed. Geology was born. Scholars began to appreciate how Earth's landscapes changed over millions of years. Yet most sixteenth-century naturalists did not acknowledge that fossils were the remains of living organisms [21], because, for example, complete plant specimens were rarely found. Therefore, a paleobotanist would name a stem one genus, a root another and leaves yet another. It is only after parts were found together that they were referred to by the first genus assigned. Still, the individual parts are often referred to by their original designation. But how do we arrive at dragons from these seemingly disparate parts?

DorothyBelle Poli (educator, researcher), Biology Department, Roanoke College, 221 College Lane, Salem, VA 24153, U.S.A. Email: poli@roanoke.edu. ORCID: 0000-0002-4739-5906.

Lisa Stoneman (educator, researcher), Education Department, Roanoke College, 221 College Lane, Salem, VA 24153, U.S.A. Email: stoneman@roanoke.edu. ORCID: 0000-0002-4986-9933.

See www.mitpressjournals.org/toc/leon/53/1 for supplemental files associated with this issue.

https://doi.org/10.1162/leon_a_01576

TABLE 1. Cultural Representations of Dragons

Time Period	In Art or Literature	Origin of Mythos
c. 5000 BCE	*Mushushu*/Dragon likeness of Marduk/Tiamat on the Ishtar Gate, Babylon, Mesopotamia	Sumerian mythology
c. 2600 BCE	*Lung* or *long*, serpentine dragon with scales, lizard legs, eagle talons	Chinese mythology
c. 1000 BCE	Feathered serpents	Mesoamerican mythology: Quetzalcoatl
c. 470 BCE	*Apollo* and *Python*, black-figure lekythos, Greek vase, Musée du Louvre	Greek mythology: serpent Python
c. 400 BCE	*The Hesperides in the Garden*, Attic red figure hydria, British Museum, London	Greek mythology: Ladon, dragon guarding apples of Hesperides
c. 400 BCE	*The Colchian Dragon Disgorging Jadon*, Athenian red-figure kylix, Gregorian Etruscan Museum, Vatican Museums	Greek mythology: the dragon and the golden fleece
c. 200 BCE	*Perseus and Andromeda*, Roman mosaic, Bardo Museum, Tunis, Tunisia	Greek mythology: sea serpent Ketos
c. 50	Pliny the Elder, *Natural History*	Roman literature: Indian and Ethiopian cave dragons
c. 900	*Historia Brittonum* (literature)	Welsh mythology: the red dragon
c. 1000	*Beowulf* (literature)	Anglo-Saxon mythology: dragon killed by hero
c. 1100	*Nibelungenlied* (literature)	Germanic mythology: Fafnir
c. 1200	*The Mabinogion* (literature)	Welsh mythology: red and white dragons fighting
c. 1200	*The Eddas* (literature)	Norse mythology: serpent Jormungandr
c. 1200	Various bestiaries (literature)	European mythology: dragons and dragon-like animals
c. 1280	*Volsunga Saga* (literature)	Norse mythology: Scandinavian dwarf prince turned into a dragon slain by Siegfried
1489–1605	1489, Bernt Notke, *St. George and the Dragon*, sculpture, Church of St. Nicholas, Stockholm 1506, Raphael, *St. George and the Dragon*, painting, National Gallery of Art, Washington, DC 1555, Jacopo Tintoretto, *St. George and the Dragon*, painting, The National Gallery, London 1559, Titian, *St. Margaret and the Dragon*, painting, Museo del Prado, Madrid 1588, van Haarlem, *Two Followers of Cadmus Devoured by a Dragon*, painting, National Gallery, London 1605, Peter Paul Rubens, *St. George and the Dragon*, painting, Museo del Prado, Madrid	European Christian mythology: St. George, St. Margaret, La Tarasque, La Vibria
1590–1596	Edmund Spenser's *Fairie Queene* (literature)	English Christian mythology
Mid-nineteenth century	1853, Utagawa Kuniyoshi, *Recovering a Jewel from the Palace of the Dragon King*, painting Triptych of polychrome woodblock prints, Metropolitan Museum of Art, New York 1853, Utagawa Kuniyoshi, *Tamatori Escaping from the Dragon Kind*, woodblock print, British Museum, London	Japanese mythology
Late nineteenth century	1881, Walter Crane, *The Laidly Worm of Spindleston Heugh*, painting, private collection, U.S.A. 1889, Gustave Moreau, *St. George and the Dragon*, painting, National Gallery, London	British mythology

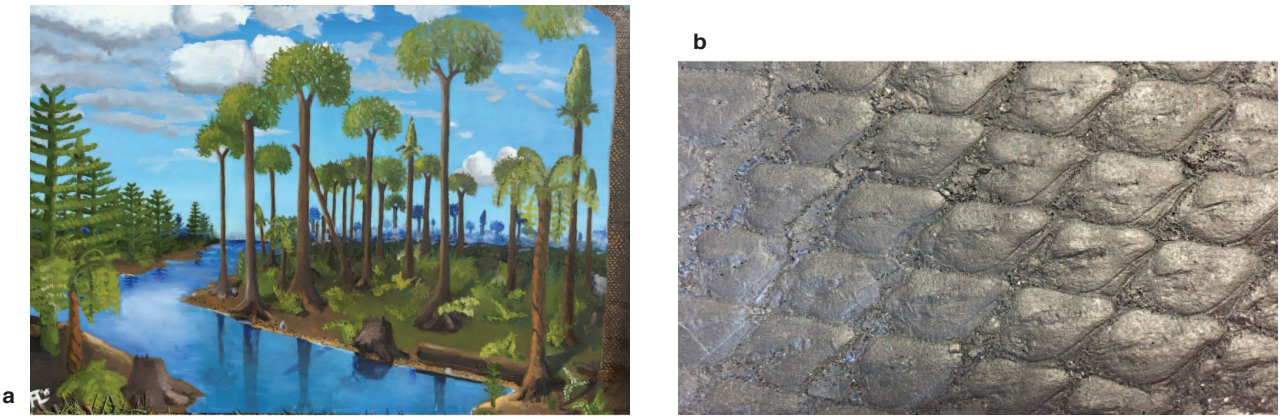

Fig. 1. (a) Artist's reconstruction of a Carboniferous-Period forest including examples of *Lepidodendron*. Travis Lumpkin, *Carboniferous Forest*, acrylic on canvas, 24 × 36 in., 2015. (© Dragon Research Collaborative, Roanoke, VA) (b) *Lepidodendron* scale pattern (© Virginia Museum of Natural History, Martinsville VA. Photo: Christina Byrd.)

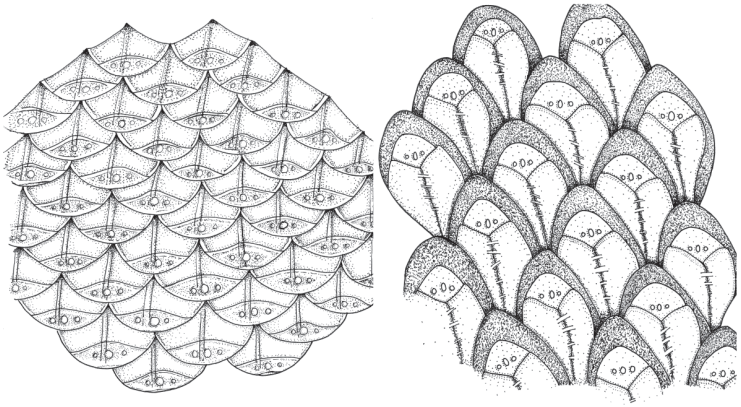

Fig. 2. Travis Lumpkin, Lepidodendron *Variations*, line art, ink on paper, 2013. (© Dragon Research Collaborative, Roanoke, VA, 2015)

Lepidodendron, a common Carboniferous Period (approximately 300 million years ago) plant fossil, stood 100 feet tall and was approximately 8–12 feet wide (Fig. 1a); the scale pattern, the result of leaves falling off throughout the plant's growth, gives the fossil a reptilian appearance (Figs 1b, 2). The root structure of this plant, *Stigmaria*, is a five-pronged structure that sits partially exposed above ground (Fig. 3a). When a *Lepidodendron* trunk is still attached to that root structure, it takes little imagination to envision a leg with a foot/claw. Branch scars (*Ulodendron* when found as solitary fossils) resemble a reptile's eye, complete with eyelid (Fig. 3b). Other Carboniferous plants in this stratum, such as tree-ferns and ferns, possessed fronds whose fossils may be misidentified as feathers (Fig. 3c). It is common for modern humans, especially laypeople, to examine fossils and misidentify them; ancient humans may have looked at what we now know to be Carboniferous plant fossils and seen what we would consider the fantastic: a dragon.

Many dragon origin theories have been put forth (see the online supplemental table). Dinosaurs may provide the inspiration for the size attributed to dragons, but discovering complete organisms in fossil form is an improbable occurrence and makes a direct dinosaur–dragon connection unlikely

Fig. 3. Additional Carboniferous-Period fossil plants. (a) *Stigmaria* (Kelin-grove Art Gallery and Museum, Glasgow, U.K. Photo © Charles Akers). (b) *Ulodendron* (branch scar). (© Virginia Museum of Natural History, Martinsville, VA. Photo: Christina Byrd.) (c) Common fern leaves. (© Virginia Museum of Natural History, Martinsville, VA. Photo: DorothyBelle Poli.)

[22]. Paleontologists Conway et al. illustrate how animal bones can be misconstrued because they do not provide sufficiently accurate clues about external appearance [23]. For example, a rabbit's characteristically long ears would not be hypothesized, as the skeleton does not reveal this information. Likewise, Adrienne Mayor describes how large fossil bones of *Deinotherium giganteum*, a prehistoric elephant relative, may have led early humans to create myths such as the cyclops [24]. When forming a hypothesis to explain dragon origins, we must consider dragons' outward appearances as described in tales and represented in art, in addition to their large size. Plant fossils give us a way to understand the worldwide consistency of the dragon's outward appearance (i.e. reptilian scales, size, feathers and feet).

PERCEPTION: CHASING THE DRAGON

Our research idea originated in a West Virginia rock quarry, where we "saw" a dragon in the rock face. What appeared as the body, legs and eye of a dragon embedded in the black and gray Carboniferous shale were actually *Lepidodendron* fossils (Figs. 1b, 2). On the basis of this initial field observation, we chose to test human perceptions of the pattern exhibited by the fossils (Roanoke College Institutional Review Board, IRB approval #15ED013).

Participants, all adults with at least some college education, were shown *Lepidodendron* casts (Fig. 1b); of these, three groups were given an open-ended writing prompt on paper: "You are walking along a cliffside when you trip over this object. It appears to be _____." Participants were asked not to confer until all had completed the task, which involved handling the fossil cast and completing the response within a 10-minute period. Responses (n=115) were approximately 25–50 words. Answers do not match the number of participants, as many responses included more than one of the coded words.

After we analyzed the responses for repeated words or phrases (Table 2), 9 code categories emerged: *scales*, *volcanic/lava/ash*, *serpent/snake*, *reptile*, *dragon*, *fire*, *char*, *fish* and *other*. These are listed in Table 2 in hierarchical order by number of responses and are undergirded by dragon folklore and critical literature that includes descriptions of creatures that are called worms, serpents, snakes and dragons. Analysis of responses assumes similar connotations for these terms and supports our plant fossil–folklore hypothesis. In addition, the perceptual connection to volcanic rock, ash, charring, scales, reptiles—and ultimately dragons—supports the contention that humans in an earlier era were likely to have reacted like our modern participants, who had the advantage (and bias) of knowing that fossils exist and that dragons are mythical. Participants not only often "saw" a beast but were willing to create a story around this idea, though the prompt did not require it. A sample response:

> The scales were too long for any fish I knew, or even any kind of snake. . . . Dragons only existed in fairy tales. But I knew it must have been for it's the only creature with scales that large.

The plant fossil–folklore investigation began in earnest after we realized that others perceived dragon-like qualities in these specific fossils. The following questions guided our research: (1) In what specific regions of the world do Carboniferous plant fossils exist, and how do they correlate with dragon folklore? (2) How do dragon folklore elements (e.g. appearance, environment, behavior) correlate with such fossils? (3) How do these fossils help us understand why a variety of cultures worldwide created myths and legends about a similar creature?

UNCOVERING THE FOSSILS: LOCATING DRAGON PARTS

During the Carboniferous Period, Pangaea was the major landmass on Earth. Plants were numerous in equatorial swamps and in prime locations to fossilize. Lycopods (*Lepidodendron* and relatives), tree ferns, ferns, *Calamites* and progymnosperms dominated the landscape (Fig. 1a). Today, shale, sandstone and, particularly, coal seams from these areas are full of the fossil remains of these physically elaborate plants. However, what was once an equatorial location is now found at different longitudes and latitudes, Pangaea having broken apart and become our current continents. Furthermore, fossilization varies in different locations, and not every location has a complete set of plants represented during those ancient times.

To identify fossil locations, we searched primary scientific literature for Carboniferous plant genera (e.g. *Lepidodendron*, *Sigillaria*, *Stigmaria*, *Ulodendron* and *Lepidophilos*) up to 2016. All these species exhibit the unique reptilian scale, chain mail or eyelike forms we saw in the West Virginia quarry face. We noted the exact locations of fossil acquisitions as reported in the literature in a chart; only sources mentioning primary fossil discovery were used. Note that plants do not grow in a single location but may represent large groves of fossils. The final data include 217 fossil locations worldwide. Fossil sites

TABLE 2. Fossil Perception Data

Code Term	Instances
Scales	47
Volcanic/lava/ash	45
Serpent/snake	44
Reptile	41
Dragon	37
Fire	21
Char	17
Other (obsidian, tar, cave rock, cliff rock, chain mail)	15
Fish	5

Prompt response narrative codes from 115 participants.
Many participants listed multiple terms.

are distributed over the British Isles, North America and Asia but also exist in Europe, Scandinavia and Australia.

The documentation of Carboniferous-Period plant fossil locations is incomplete, even though it is possible to predict where coal should be located due to proximity of a given area during Pangaea's existence. Countries do not always disclose the location of Carboniferous fossils because they may be tightly linked to proprietary coal rights. Some countries guard natural resource locations from public knowledge to protect against security threats or business competition.

Building a Dragon: Finding the Stories

Our examination of dragon folklore began with establishing criteria for what constituted a dragon tale. Keyword searches for "dragon," "folklore," "myth," "legend" and "tales" led to both folktales and literary or critical analyses of the folklore. We limited the search to English translations because these were most accessible to the research team. The search for dragon stories led to tales of worms [25], serpents [26], *taniwha* [27], *long* [28], the Rainbow Serpent [29] and *uktena* and *tlanuwa* [30]. Given our focus on story origin points, we searched for multiple iterations to divine earliest appearances. For example, the telling of St. George's dispatch of a dragon was popular in medieval Britain but appears to have originated hundreds of years earlier in the Middle East.

These searches, refined by country or region and initial geographical location, allowed data points to be logged in chart form, using the following documentation categories: (1) folktale name; (2) location (as specific as possible); (3) date of origin (if known); and (4) brief tale synopsis. In this literature, we noted several similarities in physical descriptions or artistic representations: triangular scales, clawed feet, serpentine shape and large size. We also considered the purpose or function of the beast within a particular culture, e.g. creation, treasure-guarding, human sacrifice, community scourge or beneficent gift-giver. After accounting for variants, we pinpointed 76 folktales across the world, particularly in the British Isles, North America, Asia and the Middle East.

INTERWOVEN BOUNDARIES: FINDING CONNECTIONS THROUGH MAPPING

In order to compare the plant fossil and dragon folklore data, we constructed maps using MapBox Studio [31]. When we had only approximate locations of plant fossils, we used Google Earth to gain coordinates so more centralized locations could be accurately plotted (Fig. 4). Often the locations of tale origins could be pinpointed to castles, rivers or prominent landmarks. Where tales were less localized and often more ancient, the geographic locations were drawn from as many sources as possible and then estimated, e.g. "Set, the red serpent from Egypt" [32] (Fig. 5). If a tale was known to have traveled, we did not duplicate tale points.

We overlaid the fossil and folklore world maps (Fig. 6), revealing similar global patterns. Many fossil and folklore points coincided exactly. Although correlated points appear throughout the world, given the proliferation of sites in the U.K., we chose that location as a case study to highlight ongoing research findings. United Kingdom points appear in Fig. 7 as larger maps; the corresponding references appear in Appendix A in the online supplements.

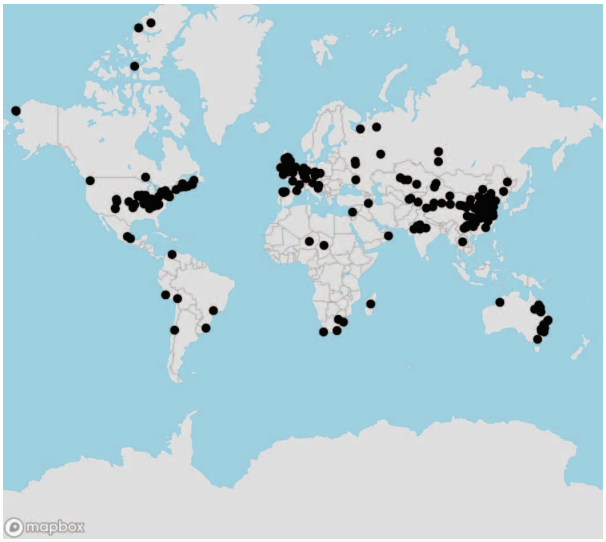

Fig. 4. World map of Carboniferous fossil plants. Map created with MapBox Studio, 2017. (© Dragon Research Collaborative, Roanoke, VA)

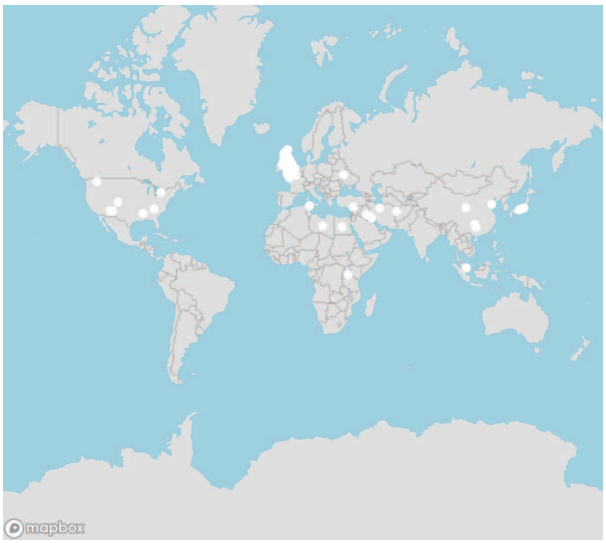

Fig. 5. World map of dragon folklore. Map created with MapBox Studio, 2017. (© Dragon Research Collaborative, Roanoke, VA)

DISCUSSION: CLOSING THE LOOP

Even though most fossils in many strata are difficult to find, one stratum is fossil-rich: the Carboniferous layer. Carboniferous plant fossils, especially *Lepidodendron*, form the major part of the coal seams found in all dragon folklore locations. English tales (see online Appendix A for references)—such as of the Lambton, Sockburn and Pollard worms in Durham; the Handale, Wharncliffe and Filey dragons in Yorkshire; and the Mosten and Wormelowe dragons in Cheshire—correspond to Carboniferous fossil beds located within a few miles' radius, near the sites of ancient (and modern) coal

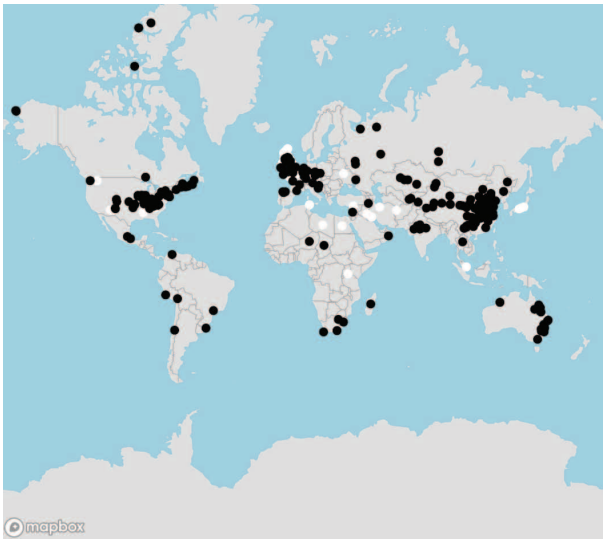

Fig. 6. World map of fossils (black dots) overlaid with folklore (white dots). Map created with MapBox Studio, 2017. (© Dragon Research Collaborative, Roanoke, VA)

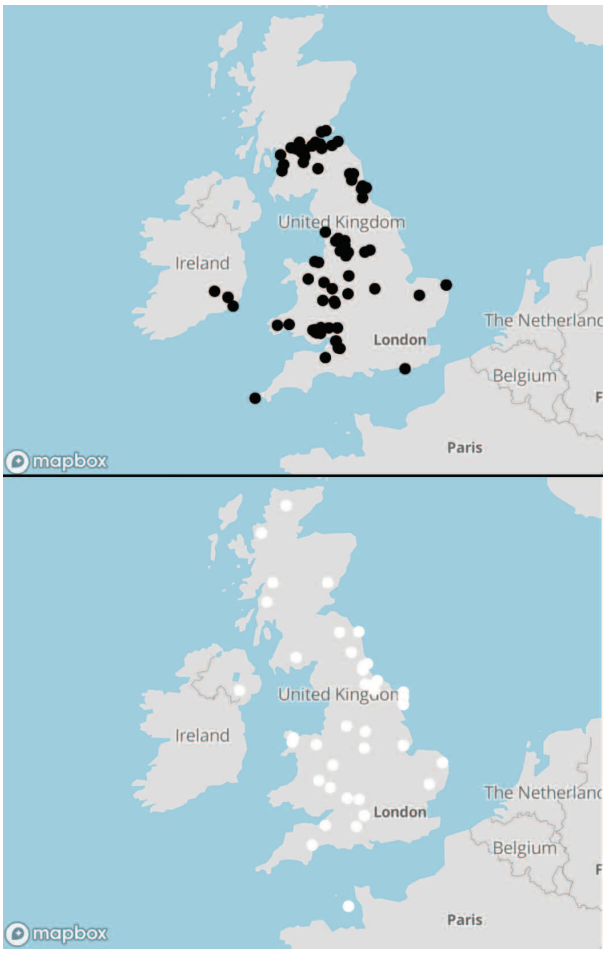

Fig. 7. Maps of the United Kingdom, 2017. (a) Carboniferous plant fossils. (b) Dragon folklore. Maps created with MapBox Studio; references in online Appendix A. (© Dragon Research Collaborative, Roanoke, VA)

mines, castles, quarries or water sources that are easily accessible, making plausible the supposition that humans had opportunity to encounter the fossils.

In a 1658 bestiary, Edward Topsell alludes to humans encountering animal fossils near limestone and marble mines that may have birthed the story of the Greek dragon of Chios [33]. In 1889, geologist Charles Gould noted a possible origin of dragons in Victorian fossilists' findings of early Iguanodon [34]. Modern theorists Justin Delair and William Sarjeant [35] concur with Gould, while Paul Newman [36] chronicles several theories, one of which is a connection to animal fossils. Mayor [37] refers to ancient historians' accounts of the Chios scenario as she describes human encounters with animal fossils engendering dragon lore.

Looking deeper into a few tales reveals their relationships to the plant fossils' appearance as well as their locations. According to lore, John Lambton yanks the Lambton worm from the Wear River on the end of a fishing line and flings it into a well, where it reaches enormous size [38]. Years later, pieces of the worm are hacked off in an effort to kill it, but it regenerates these parts and lives on. Lambton's worm grows so large that it can wrap itself around a hill seven times, a feat that causes a (still-visible) circular indentation around Worm Hill, located near a documented fossil site. Eventually, Lambton hacks the worm to pieces, which float down the Wear before the worm is finally torn completely apart, having impaled itself on Lambton's armor. Note that Lambton's estate sits at the site of lead, coal and limestone mines that have operated for centuries. Interestingly, up until the seventeenth century, coal was believed to be a living thing with "special seeds for its reproduction and growth under the ground" [39]. Could the pieces of the Lambton worm that washed down the Wear River have been the coal-black, scaly fossils of *Lepidodendron*?

The Sockburn Worm lived just a few miles from where Lambton dispatched his. The Sockburn area was an important location as far back as eighth-century Anglo-Saxon rule and was a key religious site throughout the medieval period [40]. The legend of the worm appears in text in the seventeenth century, but the tale is believed to be much older, as the medieval Conyers falchion sword figures as the weapon used on the beast. The Sockburn Worm was a black dragon whose poisonous breath killed all who came near. When Conyers slays it, the worm's head rolls down from its black lair like a boulder. The allusion to the color of the dragon's lair and his rock-like head are consistent with the plant fossil–folklore hypothesis. Also, in mines, carbon dioxide and carbon monoxide are silent killers; likewise methane can arise, hissing from rock fissures or suddenly exploding [41]. "The Mosten Dragon," a tale from the west of England, lends a concrete physical description of the dragon's hide: "Its body like a serpent low, And scaled o'er as with mail" [42]. The chain mail detail coincides with the appearance of *Sigillaria* (Fig. 8). Geat (Scandinavian) warrior Beowulf, fatally encountering "the fire-dragon . . . the breath of the monster/ [bursting] from the rock . . . raise[s] his hand and str[ikes] hard/at the enameled scales," killing the beast [43]. In North America, James Mooney describes the Uktena, said to live in

the passes of the Smoky Mountains, as "a great snake, as large around as a tree trunk . . . scales glittering like sparks of fire" [44]. Mooney relates that a man preserved a scale from the monster and "burned the Uktena scale to a coal" [45].

Examining the world map overlay (Fig. 6), it appears that many dragons may originate from the plant fossils; locations where fossils and folklore do not correspond may have used indigenous reptiles for inspiration. The discrepancy may reflect language barriers inherent in folklore study; however, it could also be that dragon myths evolved at least twice in human history. For example, in South America and New Zealand respectively the Rainbow Serpent and Taniwha may be more reptile-based, as the plant fossils lie much deeper or are not found there [46]. Therefore, our current hypothesis may evolve to include "sister-dragon species." While the U.K. provides a strong case study for the plant fossil–folklore hypothesis, plotting the plant fossil (n=217) and folklore (n=76) data points on a world map provided the perspective necessary to see a global trend. Precedent for generalizing similar data was set by Mayor, who uses relatively few data points (45 total) on maps of the Aegean and Mediterranean worlds to represent contentions related to animal fossil bones and giants [47].

A plant fossil–folklore connection does not negate other dragon origin hypotheses. There is a wide cross-section of theories ranging from dragons as living reptiles, metaphorical representatives and the rational explanation for fossilized bones encountered by early humans (see the table in the online supplements). Folklorist Hilda Ellis Davidson contends that dragon lore may have a common environmental factor. Her idea of a synergy between natural world and art remains timely:

> Archaeology here serves to illuminate the poetry and literature puts new meaning into the archaeology, and while there are many unsolved problems, it is, I believe, by such piecing together of scattered evidence from different sources that we may hope to draw nearer to an understanding of the thoughts and beliefs of a vanished age [48].

Fig. 8. *Sigillaria* fossil. (© Virginia Museum of Natural History, Martinsville, VA. Photo: Lisa Stoneman.)

Plant fossils may be the catalyst for the outward characteristics of the dragon and therefore impact the lore. In some scientific circles, studying fantastical beasts may be considered frivolous and illogical. One may contend that the magnificent dragon should not have such a plausible, seemingly mundane, genesis. But the dragon's magic is not diminished by the plant fossil–folklore hypothesis. Making this connection requires seeing around and beyond the awareness of one discipline to embrace the symbiosis of seemingly disparate fields of knowledge.

Acknowledgments

The authors acknowledge Roanoke College for financial support, Virginia Museum of Natural History for access to their fossil collection and the Dragon Research Collaborative for ongoing inspiration. Special thanks to Emma Clarke, Christina Byrd, Travis Lumpkin, Bentleigh Asboth, Charles Akers and Hannah Updike for assistance.

References and Notes

1 C. Singer, *A Short History of Biology: A General Introduction to the Study of Living Things* (Oxford: Clarendon Press, 1931).

2 Pliny, *Natural History* Vol. 3, A Rackham, W. Jones, D. Eichholz, trans. (Cambridge, MA: Harvard Univ. Press, 1997).

3 E. Topsell, *The History of Four-Footed Beasts and Serpents and Insects* (London: E. Cotes, 1658) p. 703.

4 C. Gould, *Mythical Monsters* (London: W.H. Allen & Co., 1886).

5 G. Smith, *Evolution of the Dragon* (Manchester, U.K.: University Press, 1919).

6 E. Best, "The Maori," *Memoirs of the Polynesian Society* **5**, Vol. 1 (1924) p. 186.

7 R. Molnar and M. Pole, "A Miocene Crocodilian from New Zealand," *Alcheringa* **21**, No. 1, 65–70 (1997).

8 E. Ingersoll, *Dragons and Dragon Lore* (New York: Payson & Clark, 1928) p. 6.

9 H. Davidson, "The Hill of the Dragon: Anglo-Saxon Burial Mounds in Literature and Archaeology," *Folklore* **61**, No. 4, 169–185 (1950).

10 T.H. White, *Book of Beasts* (New York: Dover, 1954) p. 166.

11 J. Fontenrose, *Python: A Study of Delphic Myth and Its Origins* (Berkeley: University of California Press, 1974).

12 M. Barnard, "A Dragon Hunt," *The American Scholar* **33**, No. 3, 425–427 (1964).

13 C. Sagan, *The Dragons of Eden: Speculations on the Evolution of Human Intelligence* (New York: Random House, 1977).

14 S. Best, "Here Be Dragons," *The Journal of the Polynesian Society* **97**, No. 3, 239–245 (1988) p. 239.

15 R. Blust, "The Origin of Dragons," *Anthropos* Bd. 95, H. 2, 519–536 (2000).

16 A. Mayor, *The First Fossil Hunters: Dinosaurs, Mammoths, and Myth in Greek and Roman Times* (Princeton, NJ: University Press, 2000).

17 C. Danforth, "Studies on Hair with Special Reference to Hypertrichosis," *Archives of Dermatology and Syphilology* **12** (1925) pp. 380–401.

18 P. Pavone et al., "Congenital Generalized Hypertrichosis: The Skin as a Clue to Complex Malformation Syndromes," *Italian Journal of Pediatrics* **41**, No. 55, 51–58 (2015).

19 E. Kaygusuz et al., "Sirenomelia: A Review of Embryogenic Theories and Discussion of the Differences from Caudal Regression Syndrome," *Journal of Maternal-Fetal and Neonatal Medicine* **29**, No. 6, 949–953 (2016).

20 Singer [1].

21 W. Buckland and S. Gould, *Geology and Mineralogy Considered with Reference to Natural Theology (History of Paleontology)* (North Stratford, NH: Ayer, 1980).

22 J. Delair and W. Sarjeant, "The Earliest Discoveries of Dinosaurs," *Isis* **66**, No. 1, 4–25 (1975).

23 J. Conway, C. Koseman and D. Naish, *All Yesterdays: Unique and Speculative Views of Dinosaurs and Other Prehistoric Animals* (United Kingdom: Irregular Books, 2012).

24 Mayor [16].

25 J. Jacobs, ed., "The Laidly Worm," *More English Fairy Tales* (New York: G.P. Putnam, 1894).

26 L. Egerton, *Ballads and Legends of Cheshire* (London: Longmans & Co, 1867).

27 Best [6]; Best [14].

28 L. Yang and D. An, *Handbook of Chinese Mythology* (New York: Oxford Univ. Press, 2005).

29 Blust [15].

30 J. Mooney, *Myths of the Cherokee. Extract from the 19th Annual Report of the Bureau of American Ethnology* (Washington, D.C.: Government Printing Office, 1902).

31 D. Poli et al., "Using MapBox Software to Help Students See Trends in Biology," *The American Biology Teacher* **78**, No. 5, 426–427 (2016).

32 V. Davis, "Serpent Myths," *The North American Review* **146**, No. 375, 161–171 (1888) p. 162.

33 Topsell [3].

34 Gould [4].

35 Delair and Sarjeant [22].

36 P. Newman, *The Hill of the Dragon: An Enquiry into the Nature of Dragon Legends* (Totowa, NJ: Rowman and Littlefield, 1980).

37 Mayor [16].

38 J. Crawhall, *History of the Lambton worm . . . to which is annexed, a prose account of the same . . . also, The laidley worm of Spindleston Heugh by Duncan Frasier, the Cheviot bard* (Newcastle, U.K.: W. and T. Fordyce, 1821–1896).

39 B. Freese, *Coal: A Human Story* (New York: Penguin, 2003) p. 57.

40 D. Went and M. Jecock, "Sockburn Hall, Darlington: An Archaeological Investigation of the Medieval and Post-Medieval Manors and the Setting of the Pre-Conquest Church," *Research Department Report Series* No. 82-2007 (2007).

41 Freese [39] pp. 48–49.

42 Egerton [26] p. 225.

43 S. Heaney, *Beowulf: A New Verse Translation* (New York: Norton, 2000) pp. 173–175.

44 Mooney [30] p. 297.

45 Mooney [30] p. 301.

46 Molnar and Pole [7].

47 Mayor [16].

48 Davidson [9].

Manuscript received 9 November 2016.

DOROTHYBELLE POLI *is an evolutionary plant physiologist who received her PhD from the University of Maryland (2005). She is also a research associate with the Virginia Museum of Natural History. She studies plant axis evolution.*

LISA STONEMAN *is a social scientist specializing in pedagogy and curriculum design. She received her PhD from Virginia Polytechnic Institute and State University. Years ago, she designed folklore courses that continue to allow her to blend her research with her avocation.*

Together Poli and Stoneman codirect the Dragon Research Collaborative, an evolving body of interdisciplinary scholars.