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Cover art: Screen capture from the game *Project Hospital*, by Oxymoron games (Prague, Czech Republic). Image is a courtesy of the studio; used with permission.

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A paleontological outlook on the *Super Mario Bros.* movie

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Among the many unique choices made while making the 1993 movie *Super Mario Bros*. was the large focus on dinosaurs. Much of the movie takes place in Dinohattan, an alternate New York in a universe where humans evolved from dinosaurs instead of mammals. This was undoubtedly inspired by various reptilian species within the Mario games. That dinosaurs were extremely popular in the 90's certainly helped. New discoveries from the Dinosaur Renaissance of the 70's and 80's inspired new dinosaur media such as T*he Land Before Time*, *Jurassic Park*, and of course, *Super Mario Bros*. *Jurassic Park* in particular ushered in a huge wave of dinosaur media, with many since bearing at least one reference to the film. *Super Mario Bros*. was the last major piece of dinosaur media to be released before the *Jurassic Park* wave, predating that film's release by only a few weeks.

NEW YORK AND THE END OF THE CRETACEOUS

The movie's infamous introduction details the extinction of the non-avian dinosaurs via meteorite impact. At the time we knew a meteorite was to blame, thanks to iridium. Iridium is an element very rare on

Figure 1. Brooklyn 65 million years ago, according to *Super Mario Bros*. It didn't look like this in real life – at the time, the area that is now New York City was at the bottom of the Atlantic Ocean.

earth, but common in asteroids, and there's a global layer of iridium in the rock record right at the boundary between the Cretaceous and the Paleogene (Alvarez et al., 1980). This even got a shout-out in *Super Mario Bros*. In the early 90's, the location of the impact site wasn't certain – but we would soon find out it wasn't Brooklyn (Fig. 1). The Chicxulub crater, buried underneath Mexico's Yucatan Peninsula, has been dated to just under 66 million years ago – right at the K-Pg boundary (Hildebrand et al., 1991). This crater is estimated to be 150 km wide and 20 km deep, created by an impactor roughly the size of Mount Everest. It would have obliterated everything within the vicinity in a frction of a second, leaving nothing behind to fossilize.

The notion of digging up tyrannosaurs in Brooklyn is also doubtful. Long Island is very recent geologically, being formed by glaciers during the last Ice Age – the same glaciers that ground away most of New York state's Cretaceous rocks (Charles Marshall, pers. comm.). But we can make inferences about what lived there based on fossils found in nearby states like New Jersey. During the Cretaceous, there was an inland seaway that split North America into two continents, Laurentia in the west and Appalachia in the east. The two continents had different faunas – Appalachia didn't have any of the famous Late Cretaceous dinosaurs Laurentia did. At the end of the Cretaceous, New York state would have been on the coast of a much narrower Atlantic Ocean, and the city was underwater.

Dinosaurs that lived on the eastern seaboard included ostrich-like ornithomimids (Brownstein, 2017), armored nodosaurids (Burns, 2016), duckbilled hadrosaurs (Prieto-Marquez et al., 2006), and *Dryptosaurus*. *Dryptosaurus* (Fig. 2) was a relative of *Tyrannosaurus*, around half the size but leaner and with larger arms (Brusatte et al., 2011). If *T. rex* was a tiger, *Dryptosaurus* would have been a leopard. In the skies flew early seabirds (Weishampel et al., 2004), and out at sea lived a variety of marine reptiles, such as sea turtles and plesiosaurs. The most famous marine reptiles, however, would be mosasaurs – large ocean-going lizards whose limbs had evolved into dolphin-like flippers. These ranged in size from the three-meter long *Halisaurus* to the fifteen-meter long *Mosasaurus* (Gallagher, 2005). Although the fossils Daisy finds may not line up with real life, Anthony Scapelli's interference with the dig is unnervingly close to reality, as many field paleontologists will tell you.

Figure 2. A life-sized model of *Dryptosaurus*, built by Tyler Keillor and on display at the Dunn Museum in Libertyville, Illinois, USA.

DINOSAURS

Jurassic Park closely followed the science of the time, bringing an updated image of dinosaurs to the public. Heavily inspired by the Dinosaur Renaissance, and the growing body of evidence that birds are a clade of dinosaurs, that movie's dinosaurs were energetic, warm-blooded, awe-inspiring, dangerous, and in some cases intelligent. As the previous public perception of dinosaurs was that of slow, lumbering, cold-blooded evolutionary failures, this brought a paradigm shift in popular culture, and a renewed interest in the science of paleontology (Liptak, 2018). *Super Mario Bros.* was not part of this paradigm shift. It's clear the filmmakers were still in the mindset that dinosaurs were cold-blooded and reptilian. The Goombas (Fig. 3) – de-evolved Dinohattanites – are dumb and lumbering. They resemble the synapsid *Cotylorhynchus* (Fig. 4) more than any actual dinosaur. Yoshi (Fig. 3) is a little more active, but he's still highly caricaturized and clearly a relic from the 80's, paleontologically speaking. Not to mention, many dinosaurs are now known to have had feathers alongside or instead of scales (*e.g.*, Godefroit et al., 2014), and it's likely that ancestrally, all dinosaurs had feathers of some sort, and only larger forms lost theirs (Yang et al., 2019).

Figure 3. Some of the dinosaurian residents of Dinohattan: Daisy, a normal dinosaur-descended relative of Dinohattan (upper left); Yoshi, a more dinosaur-y dinosaur (upper right); and a Goomba, a de-evolved Dinohattanite (below). None of these closely resemble real dinosaurs, and suffice it to say, they don't resemble their video game counterparts either.

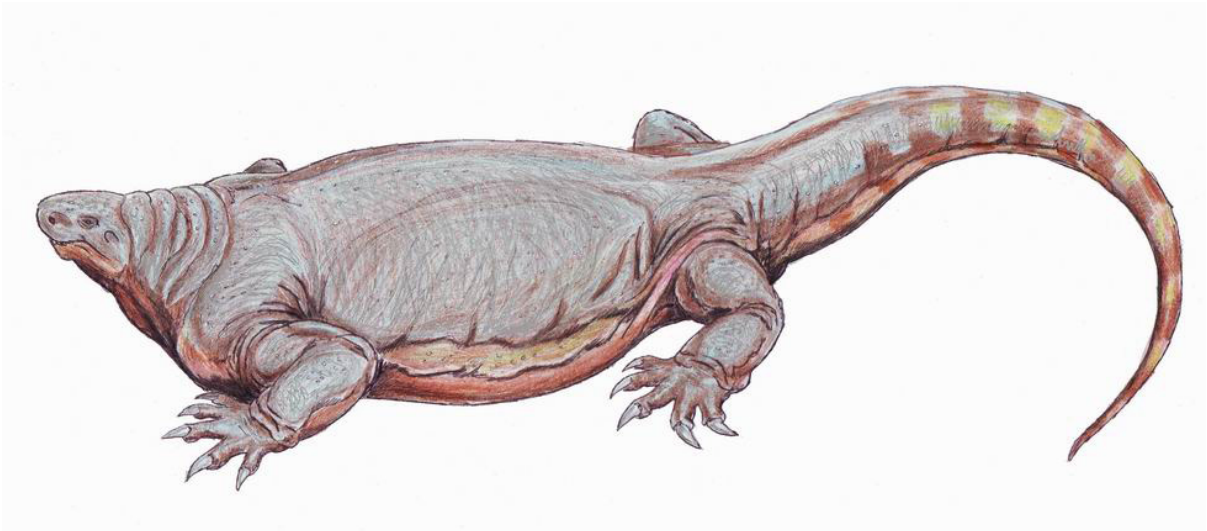

Figure 4. *Cotylorhynchus.* Despite how it may look, this is a very early relative of mammals. By sheer coincidence, it happens to resemble *Super Mario Bros.*' Goombas. Restoration by Dmitry Bogdanov.

President Koopa – who proudly brags about being descended from *Tyrannosaurus rex* – shows reptilian features such as a long, forked, flicking tongue and (sometimes) slit-like eyes. Both of these are common in living squamates (lizards and snakes), but not dinosaurs. Squamates that flick their tongues use it to gather scent particles, which is then processed by an organ in the roof of the mouth, called the Jacobson's organ. No dinosaurs had this organ (Naish, 2016). Many dinosaurs had immobile tongues, like alligators, or non-forked birdlike tongues (Li et al., 2018). The way a vertical pupil scatters light is good for predators that have their heads low to the ground – up to about the height of a cat's head (Banks et al., 2015). The vast majority of dinosaurs probably had round pupils like those of birds.

EVOLUTION AND DE-EVOLUTION

Super Mario Bros. was not the first nor the last project to speculate on what might have happened had the dinosaurs not all been destroyed. Perhaps the two cornerstone works on this topic are Dougal Dixon's *The New Dinosaurs* and the collaborative online *Speculative Dinosaur Project*, both of which detail creatures that could have evolved 65 million years after an asteroid impact that never happened. Indeed, *Super Mario Bros.* wasn't even the first to feature dinosaurs evolving into intelligent (…to a degree) life. The first to pose the question was none other than Carl Sagan, inspired by then-new research on the brain size of a family of dinosaurs called troodontids (Sagan, 1977). These dinosaurs, including the likes of *Stenonychosaurus* (Fig. 5) and *Saurornithoides*, were small-to-medium-sized omnivores with a very large brain relative to body size. In these ways they're a lot like the ancestors of humans, and thus are good candidate for evolving into sapient beings. Paleontologist Dale Russell took this a step further in 1982, with the "dinosauroid" – a human-shaped descendant of *Stenonychosaurus* (Russell & Séguin, 1982). He even commissioned a life-sized model (Fig. 5), which looks a bit more like an alien than a dinosaur. The dinosauroid isn't human to the same degree as the residents of Dinohattan, but it may have provided some inspiration for the filmmakers.

The film's idea of evolution has also not exactly held up. "You may think of evolution as an upward process," muses President Koopa right before he de-evolves Toad into a Goomba. It isn't. Evolution isn't about levels, with "basic" life progressively evolving towards a more advanced endpoint. Dale Russell certainly thought it was, which is why the dinosauroid looks so human-like (Darren Naish, pers. comm.). But evolution isn't a constant progression towards a form that's intrinsically "more advanced". An

entire rundown of the theory of evolution is out of the scope of this paper, but in short, it is simply change over time (Darwin, 1859). This is often in response to environmental change, where features that help the organism better survive and reproduce are selected for (but sometimes things evolve solely because they help the organism reproduce, for example the tail of the peacock). If a certain set of features works, there may not be reason to change much. Fossil horseshoe crabs and lungfish dating to the Jurassic are effectively identical to those around today, for example.

Figure 5. Dale Russell's Dinosauroid statue, next to a contemporary reconstruction of *Stenonychosaurus*. Compare and contrast to the residents of Dinohattan.

The "linear" idea of evolution forms the basis of *Super Mario Bros.'* de-evolution. De-evolution isn't a thing. Evolution acts with no foreknowledge or back-knowledge. An organism can theoretically evolve to superficially resemble one of its ancestors, but the mechanism behind this is no different than it evolving into something that looks completely different. This is a principle called Dollo's Law – an organism can never return exactly to the evolutionary state its ancestors had (Gould, 1970). You can't de-evolve something to what it'd be like in the Cretaceous. And since evolution acts on populations, not individuals (Darwin, 1859), the notion of de-evolving someone in particular is impossible.

CONCLUSION

Between the movie's bombing among critics and audiences upon release and *Jurassic Park* being released a few weeks later, *Super Mario Bros*. never got an opportunity to leave a mark upon dinosaur media. It does leave a legacy technologically, though: the digital visual effects techniques, many of which were invented for the film, have since become industry standards, and the Yoshi animatronics set a standard for later dinosaur movies to live up to (they even impressed the producers of *Jurassic Park*). *Super Mario Bros*. was also the beginning of John Leguizamo's inexplicable connection to prehistoric life – he would later lend his voice to the Ice Age franchise and the movie adaptation of *Walking with Dinosaurs* in 2013. And it left us with a few choice words of wisdom: trust the fungus.

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About the author

Henry Thomas is a paleontology student at the University of California, Berkeley. His main research interest is pterosaurs, which the *Super Mario Bros*. movie unfortunately lacks.

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Project Hospital: a realistic take on hospital simulation

Interview with Jan Beneš

Project Hospital[1] is a game developed by indie studio Oxymoron games (Prague, Czech Republic). In it, you build and manage every single detail of your own hospital – and you can diagnose and treat patients as well! Launched in 2018 on Steam, the game features a wealth of real-world-based medical expertise, equipment and diseases and injuries, counting with an in-depth diagnosis process.

To understand how all of this is possible in a game, the Journal of Geek Studies interviewed Jan Beneš, lead programmer at Oxymoron games. We uncovered the story behind *Project Hospital*, which you can read below.

Q: There are a few hospital and "medical" sim games around, but *Project Hospital* is a fresh and more down-to-Earth example of this subgenre. How the idea for this game came to be?

A: The story began like this: a small group of developers met in early 2016 to discuss starting a new studio and hopefully agree on the first project. Most of us are now team members or co-founders of Oxymoron games and as it turned out, *Project Hospital* was definitely a good choice of a game that we'd be both able to create with a team of 2–4 people and which would find its place on the market thanks to the combination of theme and realistic settings. The

[1] You can find it at http://www.oxymoron.games/

original pitch itself came from Roman, who then took the role of lead designer and main artist on the project.

Q: Have you or anyone in the team worked in a hospital before?

A: Actually yes, one of our designers has some experience from medical school combined with an internship in a hospital, and while he took a different career path later, his familiarity with the field was essential when choosing and creating content for the game.

Q: Did you contact staff from hospitals (admins, nurses, physicians, etc.) for advice when developing the game?

A: When we announced that the project was in development, quite a few real-life doctors and professionals in the medical field got in touch and we spent a lot of time discussing different topics in a private section of our forums. This really helped, for example, with choosing the best terminology for different aspects of the game and to some extent to see if we can get away with some of the necessary steps needed when transforming a very complex topic into a game, while advertising the realistic settings.

Q: How much realism did you set out to include in *Project Hospital* and how this realism was balanced with gameplay and entertainment?

A: The foundations based on real-world medicine gave us clear boundaries, but to create an engaging game, gameplay must come first. To be more specific, this means choosing a correct level of simplification and turning complex material into rules like "examinations uncover symptoms", "uncovering enough symptoms leads to a clear diagnosis". In the next step, it was necessary to adjust a lot of values to create interesting cases for the players to solve — for example, the occurrence rate of certain symptoms in different diagnoses was needed to be set in such a way that would limit cases where it's immediately clear what the patients are suffering from after first examination.

The process was a bit easier on the side of hospital management — and while this wasn't the actual goal and we carefully bal-

anced the economy aiming for a challenging experience — it turns out that the simulation is actually very close to the American healthcare system[2], which is both fascinating and pretty scary.

Q: So, let's delve into some of that gameplay now, shall we? What is the players' actual goal in *Project Hospital*?

A: In our elevator pitch for *Project Hospital* we always mentioned that the game would allow players to focus on different aspects, whether it is the building part with all the little details, managing a huge hospital and making it as efficient as possible, or taking care of individual patients. The latest version of the game still follows these rules as far as possible and on top of that, for players looking for more structure, we added a short campaign with some interesting tasks to undertake.

Q: Does the game allow specialization in particular subfields of medicine? Like making your hospital a reference in ophthalmology or oncology, for instance.

A: The content is indeed structured into individual departments and you can focus on any of them in any particular build, as well as running only a clinic. The five main fields available in the base game include for example cardiology, neurology and orthopaedics, with more planned for future DLCs and more also getting added by the community thanks to mod support. Oncology would be an example of a field we didn't select ourselves, but has been already added to Steam Workshop.

Q: From what we've seen, there are different objectives to be met, like solving complex cases, keeping staff and patients happy, and make profit with your hospital business. Is there a trade-off between these objectives in the game?

A: The game generally rewards you for taking good care of your employees and patients alike, so there should be no conflict between being a good manager and help-

[2]See also Boudreau, I. 2009. 'Project Hospital' is a great way to understand our broken healthcare system. Available from: https://www.vice.com/en_us/article/wjvxk5/project-hospital-is-a-great-way-to-understand-our-broken-healthcare-system (Date of access: 19/Feb/2020).

ing your staff with complicated cases when needed. For the players who want to focus on one specific goal, the game tries to help by making almost every aspect automated to some extent. Not interested in building? Try one of the pre-built hospitals or place whole rooms using the collection of prefabs. Not up to dealing with individual patients? Hire experienced staff and let them do their job.

Q: One cool thing in *Project Hospital* is to solve difficult cases. When doing so, the player is unknowingly making use of decades of real medical research. Is there a nod in the game towards scientific research and how medical knowledge evolves?

A: From this point of view we use one snapshot in the development of modern medicine — the systems are already pretty complex and quite demanding for new players, so for example researching new and more effective types of medicine didn't become a priority. There's definitely enough challenge already in finding the correct diagnosis, uncovering all potentially dangerous hidden symptoms and treating the patients on time.

Q: Unfortunately, there is a current trend of once-eradicated diseases making a resurgence. So, when you're dealing with an infectious disease in the game, is there any discussion or statement about prevention, vaccination, etc.?

A: This is definitely an interesting topic, but has mostly fallen out of scope of the main release — that said, we'll still have opportunities to tackle some of these aspects in the future and it's true that with the recent news regarding the coronavirus outbreak[3], we've been even getting similar requests from the player community.

Q: Do you think there is an educational potential for *Project Hospital*?

A: In a way, *Project Hospital* contains a pretty extensive encyclopedia of medical conditions, symptoms and diagnostic methods. While, for example, a lot of the prob-

[3] The virus has now been named COVID-19. See more at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019

abilities in the background are balanced more towards generating interesting cases than strictly following reality, there's a lot to learn from the game.

And while we can't really share more details at this moment, a couple of institutions have been evaluating the game for the use in training (I guess more for managers than doctors, but still…).

Q: So far, have you received feedback from the medical community? What has that been like and how does it differ from regular player feedback?

A: We're amazed how big a part of the player base are actual doctors or people with doctors or nurses in their family — and an obvious observation, their real-world experience indeed makes it much easier for them to get into the game.

About the Team

Oxymoron games is an indie game studio based in Prague, founded by a small group of Czech industry veterans. They have experience both at home and abroad, having worked on various game genres and interesting titles like *Mafia II & III*, *Quantum Break*, *Top Spin 4* or *Euro Truck Simulator*. In 2016, they finally found themselves at the right place in the right time to have a shot at becoming independent. After the successful release of their first game, *Project Hospital*, they're currently working on more content and supporting their player base, while preparing for future adventures.

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Fossil Pokémon and the foibles of Paleontology

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Paleontology is the scientific study of life in the geologic past, which is visible to us today in the form of fossils. It studies the evolution and diversity of life throughout the entire history of our planet up to the beginning of the Holocene Epoch (roughly 12,000 years ago). That is not restricted to just naming extinct species; we can discover all sorts of stuff by analyzing the fossil record, from parental care in dinosaurs to the great extinction events that happened on our planet. I'm giving these examples because dinosaurs are the very first thing everyone thinks about when they hear the word fossil. Or almost everyone; if you're a Pokémon trainer, you might instantly recall some of the fossil monsters in the game, most likely those from Gen I, Omanyte, Kabuto, and Aerodactyl.

From the first game in the series onwards, there are fossil Pokémon that you can find in rocks (including amber) and then revive in a Jurassic Park-esque style. The player would find such rock (for instance, a Helix Fossil) and then take it to the Pokémon Lab, where the scientists would revive it. In our example, the Helix Fossil would become an Omanyte, which is arguably the best Pokéfossil ever.[1] Every new generation of Pokémon had new fossils, with the exception of Gen VII (*Sun & Moon*).

After the break in Gen VII, Gen VIII (*Sword & Shield*) brought the fossils back, albeit in a nightmarish form. There are four types of fossils to find in the Galar region of *Pokémon Sword* and *Pokémon Shield*: Fossilized Bird, Fossilized Drake, Fossilized Dino and Fossilized Fish. However, you do not use them straightforward to get a Pokémon; a Fossilized Bird will not grant you a cool extinct bird like *Confuciusornis* from the Cretaceous Period of China. Rather, you take two different fossils to a self-entitled Pokémon professor and she will mix them

Figure 1. The fossil Pokémon chimeras from Sword & Shield. From left to right: Dracozolt, Arctozolt, Dracovish, Arctovish. Artwork from the games; images retrieved from Bulbapedia (https://bulbapedia.bulbagarden.net/).

[1] And the only one to ascend to godhood. Read the story of Lord Helix in the article by Salvador (2014).
[2] A Fossilized Bird plus a Fossilized Drake will give you Dracozolt; Bird + Dino = Arctozolt; Fish + Drake = Dracovish; Fish + Dino = Arctovish.

both to create a horrid chimera (Fig. 1).[2] The resulting Pokémon are horrid mixes that will in all likelihood have a miserable existence – just look at them, it's almost as horrible as Nina's story in *Full Metal Alchemist*.

I find it difficult to decide whether this was just some game developers running wild during character creation brainstorming sessions or if said developers knew enough about Paleontology to make a bold statement against the mistakes and the forgeries that pop up in this field every now and then. Given other biological nonsense in the series (for instance, see Tomotani, 2014; Salvador & Cavallari, 2019), I am more inclined towards the first hypothesis. Even so, I would like to explore the second one here.

Below I will delve into mistakes in fossil interpretation, from centuries-old scientific works to the present-day, and will also scrutinize the insidious fakes that people have fabricated for various reasons. But first, let us take a closer look into the fossil record.

THE FOSSIL RECORD

Paleontological science is entirely dependent on the fossil record. In broad terms, a fossil is formed when a living organism dies, get buried in the sediment and, over time, becomes petrified as the sediment turns into a rock. As you can imagine, not every organism will be "lucky" enough to get buried in appropriate sediment. For instance, carcasses might get torn apart and be eaten, plants will be decomposed and "vanish", or the weather and environmental conditions might erode and destroy an organism's remains.

Besides, not all organisms will fossilize. If they have hard parts like bones, teeth or shells, they will more likely become fossils. Mollusk shells and shark teeth are among the most common fossils to find. However, soft-bodied organisms only fossilize when conditions are extremely favorable; think about jellyfish and squid, for example. Thus, only a small fraction of all past life got fossilized. And of that small fraction, we have only found a small portion; we haven't searched all the rocks on the planet – there are several areas out there still to be explored.

As such, in Paleontology we work with very incomplete data. And to add insult to injury, sometimes the conditions of the fossils we find are less than optimal, which will make any research difficult. Just compare the fossils in Figure 2: one is neatly preserved, where all structures can be seen and studied; the other is a complete mess and barely recognizable as a snail.

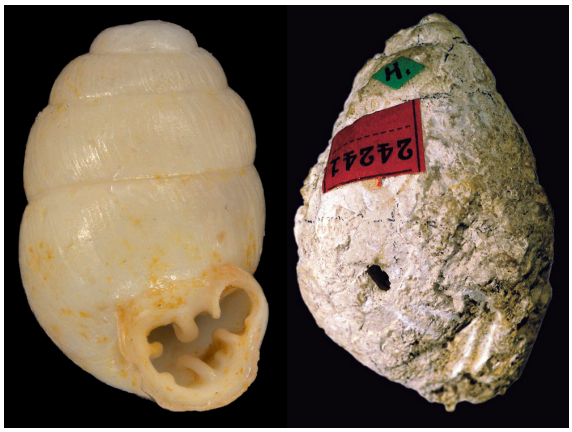

Figure 2. Left: shell of a *Vertigo* land snail from the European Pliocene (33–28 Ma), showing amazing preservation (the shell measures about 1.8 mm); specimen RGM 550.111, from Naturalis Biodiversity Center. Right: shell of an *Eoborus* land snail from the Paleocene of Brazil (roughly 58–55 Ma), showing very poor preservation (the fossil measures 44 mm); specimen AMNH 24241, from the American Museum of Natural History.

All of this makes research in Paleontology heavily dependent on the specimens one has available. Sometimes, poorly-preserved fossils will result in erroneous interpretations. These are honest mistakes that will eventually be corrected when new fossils, new data or new tools come into play. Getting it wrong the first time around is not lame or shameful – careful re-analysis and correction of mistakes is an important way in which scientific knowledge advances. So, let us take a look in some famous examples of honest mistakes.

The reversal of *Hallucigenia*[3]

Hallucigenia is a genus of weird marine worm-like creatures, full of spikes and soft appendages. The first species was discovered from the Burgess Shale, a now-famous fossil deposit in British Columbia, Canada, which dates back to the Cambrian Period (roughly 508 Ma[4]). That is the time known as Cambrian Explosion, when all animal groups were rapidly[5] diversifying into all the different branches that we know today.

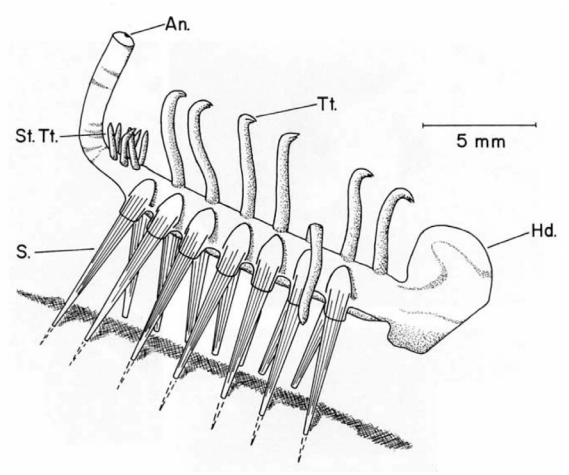

Figure 3. Morris' reconstruction of *Hallucigenia* sparsa from the Burgess Shale. Image extracted from Morris (1977: text-fig. 2A). Abbreviations: An. = anus; S. = spine; St. Tt. = short tentacle; Hd. = head; Tt. = tentacle.

At first, *Hallucigenia* was thought to be a kind of polychaete worm, but it was later interpreted as something different. Morris (1977) proposed it was a distinct branch of the animal evolutionary tree[6], and reconstructed the animal walking on its spikes, with the soft appendages floating in the water (Fig. 3). In retrospect, it is rather silly to suppose an animal would walk on stiff legs and some researchers even pointed that out at the time (Gould, 1989), but it was the only interpretation available.

Only later, researchers working on *Hallucigenia* species from Chinese Cambrian rocks were able to figure out that the spines were protective structures on the animal's back and that it walked with soft legs (Ramsköld & Xianguang, 1991). They basically flipped the animal. Also, those researchers proposed that *Hallucigenia* actually belonged to the phylum Onychophora. Nowadays, we known onychophorans as velvet worms and there are only terrestrial species remaining. The entire marine branch of this phylum (which included *Hallucigenia*) became extinct.

But the story did not end there. Smith & Caron (2015), working with better preserved material from the Burgess Shale, realized that what people thought it was the animal's tail was actually its head (Fig. 4). So *Hallucigenia* was reversed once again, only this time rotated on a different plane. This shows how difficult it is to work with fossils when they are not well-preserved or belong to groups that are entirely extinct.

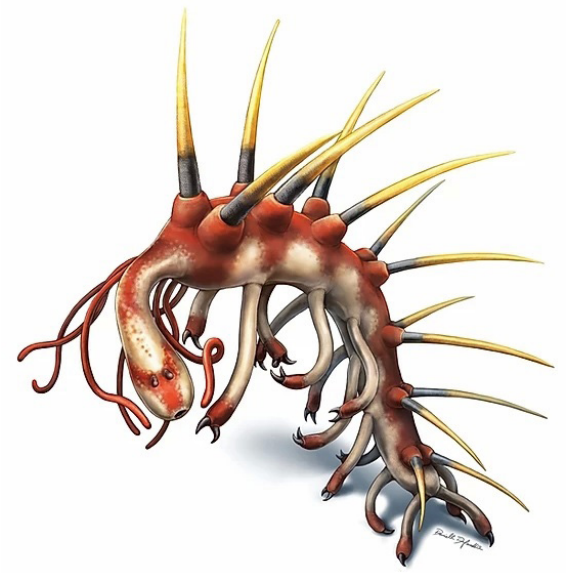

Figure 4. Artistic reconstruction of *Hallucigenia sparsa*. Illustration by Danielle Dufault (https://www.ddufault.com/), extracted from Smith & Caron (2015: fig. 3f).

[3] Yes, I borrowed the title from Steve Gould (1992).
[4] Ma = megaannum, or millions of years.
[5] Rapidly in geological terms, of course. What are 15 to 25 millions of years for a planet that is 4.5 billions of years old?
[6] He was also the one who named it *Hallucigenia*, because it is such a weird-looking beast.

The terror shrimp

The Burgess Shale was the home of a myriad of weird and wonderful creatures. My personal favorite is *Anomalocaris*. When it was first discovered (Whiteaves, 1892), the species *Anomalocaris canadensis* was described based on a fossil like the one shown in Figure 5. The genus name means "anomalous shrimp", because the fossil was deemed to be a weird sort of shrimp (it was thought to be lacking its head).

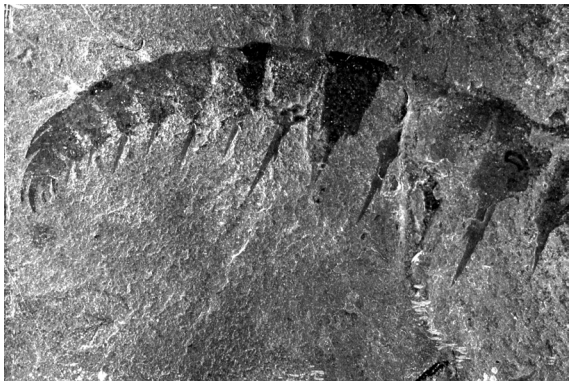

Figure 5. *Anomalocaris canadensis* (circa 8.5 cm long); specimen YPM 35138 from Yale Peabody Museum of Natural History. Image extracted from Wikimedia Commons (James St. John, 2014).

Well, you might be thinking "that's a pretty lame fossil to have as favorite", but please bear with me for a moment. Meanwhile, two other fossils were discovered in the Burgess Shale: the jellyfish *Peytoia nathorsti* (Fig. 6) and the sea cucumber *Laggania cambria*, both described in the same paper (Walcott, 1911).

It took several decades and new fossils (Fig. 7) for paleontologists to realize that *Anomalocaris*, *Peytoia* and *Laggania* were actually just parts of a single animal (Whittington & Briggs, 1985). The bit called *Anomalocaris* corresponds to the frontal appendages of the animal; *Peytoia* is the mouth; and *Laggania* the body.[7] Because *Anomalocaris* was the oldest name (the first one described), it is the one that remains used.

This is an honest mistake, even more than that of *Hallucigenia* above; it is still related to problems of fossil preservation, but in this case, it is an issue of only partial information (and partial fossils) being available.

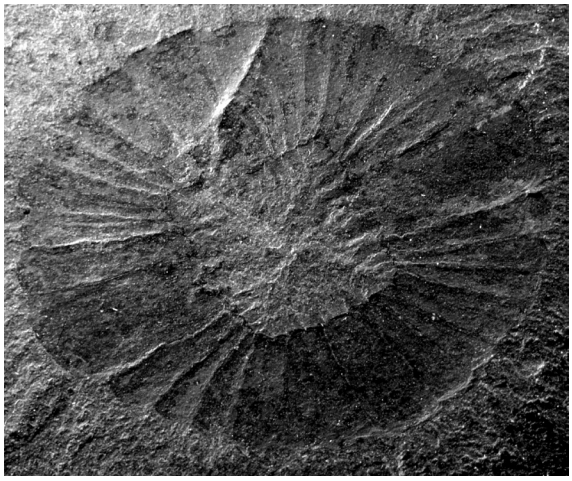

Figure 6. *Peytoia nathorsti* (circa 5.2 x 4.2 cm); specimen YPM 5825 from Yale Peabody Museum of Natural History. Image extracted from Wikimedia Commons (James St. John, 2014).

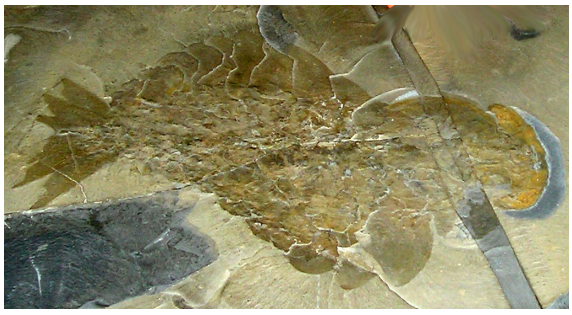

Figure 7. The first complete *Anomalocaris canadensis* ever found; specimen from the Royal Ontario Museum. Image extracted from Wikimedia Commons (Keith Schengili-Roberts, 2007).

Anomalocaris was then reinterpreted as the topmost predator of the Cambrian fauna. It was massive for its time, about 1 meter long, and possessed nasty-looking grasping-&-crunching appendages (Fig. 8) to deal with hard-shelled mollusks and trilobites. As a proficient hunter, *Anomalocaris* had dichromatic color vision and eyes composed of 16,000 lenses, rivalled only by modern dragonflies (Paterson et al., 2011; Fleming et al., 2018). They belong to a branch of the tree of life named Dinocaridida ("terror shrimps"), which is an ancestral

[7] Actually the mouthpart of *Anomalocaris* is different an the fossil known as *Peytoia* belongs to a second species of anomalocaridid.

group of phylum Arthropoda.

Finally, if you are thinking the reconstruction from Figure 8 looks familiar, that's because the Pokémon Anorith (Fig. 9) from Gen III is obviously an *Anomalocaris*.

Figure 8. Artistic reconstruction of *Anomalocaris canadensis*. Image extracted from Wikimedia Commons (PaleoEquii, 2019).

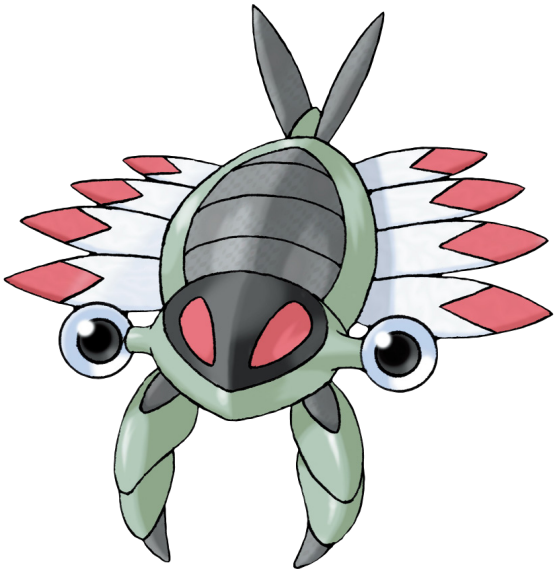

Figure 9. The fossil Pokémon Anorith from Gen III. Artwork from the game; image retrieved from Bulbapedia (https://bulbapedia.bulbagarden.net/).

A falsely accused dinosaur

Oviraptor is a genus of small theropod dinosaurs, of the kind that already looked very bird-like. They lived in Mongolia during the Late Cretaceous (90 to 70 Ma) and received their name means "egg seizer". Osborn (1924) gave them such name because the fossil skull was found lying directly on top of a nest of dinosaur eggs, which "immediately put the animal under suspicion of having been overtaken by a sandstorm in the very act of robbing the dinosaur egg nest" Osborn (1924: 9). Back then, Osborn thought the eggs belonged to another dinosaur, *Protoceratops andrewsi*.

It took a long time for people to realize the skull belonged to a parent sitting on its nest (Barsbold et al., 1990; Norell et at., 1995; Clark et al., 1999, 2001). Contrary to the examples above, the interpretation of *Oviraptor* as a thief was not due to poor fossil preservation or to the fossil belonging to a completely "alien" group. This time the interpretation hinged on a thieving raptor versus a caring parent. So how could Osborn and a whole bunch of early 20th century paleontologists get it so wrong?

In short, it was an obsolete paradigm that prevented them from seeing what is now obvious to us. Back then, dinosaurs were seen as dumb cold-blooded beasts. Only in the 1960's the so-called dinosaur renaissance began, where the paradigm started to shift.[8] A new wave of paleontologists started to understand dinosaurs as warm-blooded and active animals, with complex behavior and social structures. The work of Horner & Makela (1979), showing that *Maiasaura peeblesorum* cared for its young, was a complete breakthrough and changed the way we understand dinosaurs and how they are related to their present-day survivors, the birds.

Cope's *Elasmosaurus*

I will only touch very lightly on this example, because it is so well-know. If you're interested to know more, the book *Dinosaur Bone War* by Kimmel (2006) is a great start.

The first specimen of the giant marine reptile *Elasmosaurus platyurus* was described by paleontologist Edward D. Cope

[8] This renaissance ultimately led to a shift in how the public perceived dinosaurs too, largely due to the film version of *Jurassic Park* (Litpak, 2018; Thomas, 2020).

in 1868. When he reconstructed the skeleton, though, Cope thought the animal had a long tail and a short neck, where he obviously attached the skull. Paleontologists soon realized that the animal actually had a short tail and a very long neck and Cope's skeleton had its head on its ass, so to speak. This caused quite a stir and Cope soon became the butt of jokes by his arch-nemesis Othniel C. Marsh. This fact kickstarted what later became known as Bone Wars.

FORGERIES

All the examples above were honest mistakes. A series of erroneous interpretations were made, but in the end, they were identified and corrected. That's how things work – our scientific literature is only temporary, representing the objective truth we have at a given point in time. But eventually, everything will (or at least should) be checked and corrected or refined as necessary.

Next, we will take a look at the dark side of Paleontology. These are not fossils mistakenly interpreted; rather, these are actual fakes and forgeries made for a series of typically-human reasons.

The Lügensteine

The Würzburger Lügensteinen[9] (German for Lying Stones of Würzburg) is one of the most curious stories in Paleontology, back from a time this whole scientific field was not quite yet formed. In 1725, Johann Beringer, a professor from the University of Würzburg, found several amazing fossils on a mountain near the city: lizards, frogs, arthropods, all extremely detailed and apparently well-preserved. He also found "fossils" of other stuff, like comets and letters spelling out the Tetragrammaton (the Hebrew name of the biblical god).

Do keep in mind that this was a time when the mechanisms of fossilization and evolution were not yet understood, so we should avoid judging it by our modern standards (Gould, 2000). Beringer took these fossils seriously and published a book entitled *Lithographiæ Wirceburgensis* in 1726, describing his finds. Beringer interpreted the animal fossils as, well, fossilized animals, and considered the other stuff as "capricious fabrications of God" (Jahn & Woolf, 1963).

It turns out the "fossils" were sculpted and planted there by two of his colleagues, Ignatz Roderick and Johann von Eckhart, who wanted to discredit Beringer. The duo started to plant fakes that were progressively more absurd, but it went on for so long that they eventually decided that the prank was getting way out of hand. They tried to convince Beringer that the fossils were fake (without implicating themselves, of course), but he dismissed them, feeling he and his work were under attack.

Because of that, Beringer took Roderick and Eckert to court to "save his honor". The duo confessed they were the perpetrators of the hoax and wanted to discredit Beringer because "he was so arrogant and despised us all" (Jahn & Woolf, 1963). The whole deal ended up discrediting Beringer and ruining the reputations of the other two. The fossils became known as Lügensteine, or Lying Stones, and some are still around (Fig. 10).

Figure 10. Three Lügensteinen on display in the Senckenberg Naturmuseum (Frankfurt). Image extracted (and cropped) from Wikimedia Commons (MBq, 2018).

This is a story where everyone was wrong. The duo of forgers, obviously, no matter how much of an "insufferable ped-

[9] Also known as Beringersche Lügensteine, or Beringer's Lying Stones, after their infamous "discoverer".

ant" (Gould, 2000: 21) Beringer was. And Beringer himself, who even by the scientific standards of his day, should have done a better job instead of falling prey to an easy road to fame (Gould, 2000).

But that's all in the past, isn't it? Paleontologists nowadays are great scientists who won't be fooled, right? Well…

Spider-Lobster and the Invisible Hand

In 2019, a group of paleontologists described a giant spider species from the Early Cretaceous of China (Cheng et al., 2009). It was named *Mongolarachne chaoyangensis* (Fig. 11) and was unlike any other spider we knew about. It turns out that was due to quite an obvious reason: it was not a spider. Instead, the fossil was a crayfish with two extra legs painted on it!

Other paleontologists discovered the mistake and corrected it very quickly (Selden, 2019). But why would someone paint those legs to create a fake spider in the first place? According to Paul Selden, who spotted the issue, in China these fossils are "dug up by local farmers mostly, and they see what money they can get for them" (Lynch, 2019).

There is a huge market for embellished fossils and complete fake fossils out there. China, Morocco[10] and Brazil are especially infamous for this (Gould, 2000; Pickrell, 2015; Lynch, 2019). Typically, the fakes are restricted to dinosaurs and other large vertebrates, because that's where the big money is. Most of these "fossils" end up bought by private collectors, but sometimes a "specimen" finds its way to a museum or university and becomes part of the scientific discussion (Lynch, 2019), like the "spider" above.

These forgeries are very skillfully done, often starting with fragmentary fossils and carving out the missing parts from the stone (Pickrell, 2015). So yes, even scientists can be fooled by them, just like art curators and archaeologists are every now and then fooled by "Renaissance" paintings, Van Gogh's "Sunflowers", or a bunch of "Dead Sea Scrolls" (Gould, 2000; Subramanian, 2018; Burk, 2020).

Because of that, several fossil species have been put in check since their description and sadly the field of Paleontology has been marred by an initial feeling of mistrust whenever a new fossil (for instance, a feathered Chinese dino-bird) is discovered (Pickerell, 2015).

Figure 11. Fossil of *Mongolarachne chaoyangensis*. Image extracted from Cheng et al. (2009: fig. 1).

In all cases above (the lying stones and the "embellished" fossils), the fakes were unknown to the scientists involved. But what about forgeries purposefully-built by a researcher? Are there any of those in Paleontology? The answer is, unfortunately, yes.

[10] See Gould's 2000 book *The Lying Stones of Marrakech* for an essay linking the big forgery industry of Morocco with Beringer's Lying Stones.

The Piltdown Man

The next example is strictly speaking paleontological, although many would argue that hominin fossils fall into a particular subset of Paleontology or even into a separate field altogether: Paleoanthropology. The following story, like Cope's *Elasmosaurus*, is very well known, so I'll just touch upon it briefly. There are several books published about the Piltdown Hoax, so if you're interested, a quick search online will give you plenty of options.

To make a long story short, in 1912, a British amateur archaeologist named Charles Dawson claimed that he had discovered a hominin fossil in Piltdown, England, which was the "missing link" between large apes and humans. The species was named *Eoanthropus dawsoni* (popularly known as the Piltdown Man) and the fossils included skull fragments, a jawbone, and a canine tooth. The fossils were a forgery created by Dawson and planted on the "archaeological site" (De Groote, 2016). The jawbone and tooth belonged to an orangutan and were physically and chemically altered and prepared by Dawson. The skull fragments belonged to two humans.

Dawson and his colleagues never let other scientists analyze the actual fossils, just handing out casts of the fossils – like that was not suspicious! Only in 1953, almost 4 decades after Dawson's death, the forgery was discovered (Weiner et al., 1953). And only in 2016 researchers were able to confirm Dawson as the forger (De Groote et al., 2016).[11]

Why did he do it? Clearly for the fame (was he expecting a knighthood, maybe?) and the attention that his "discovery" garnered – it put the UK at the forefront of Paleoanthropology, attracting interest from both scientists and the general public (De Groote, 2016).

BACK TO POKÉMON

All the new fossil Pokémon from the Galar region fall into the second category explored above, that is, of fakes and forgeries. It's not their fault, of course. The fossils could be reconstructed properly; you'd just need two bits from the same species: two Fossilized Drake items, for instance, would result in a complete dinosaur, probably *Stegosaurus*-like. In fact, several fans have recreated what the actual fossil species would look like (*e.g.*, Fig. 12; but you can find more examples online).

The Pokémon "scientist" from Galar is a self-entitled expert, creating fake fossils for her own ends, just like Charles Dawson. The chimeric "species" even have spurious Pokédex entries[12], just like the "facts" about the Piltdown Man were once published in

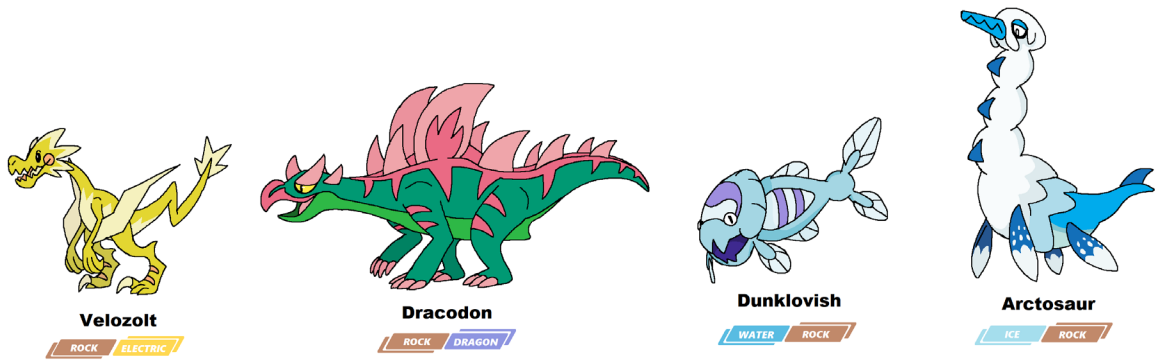

Figure 12. Reconstruction of the complete fossils from Galar region. Artwork by JWNutz (https://www.deviantart.com/jwnutz); used with permission.

[11] The Piltdown Man was not Dawson's only forgery, though; he has tens of others on his portfolio (Walsh, 1996; Russel, 2013).
[12] Granted, several other Pokédex entries seem to have been written by an 8-year-old child. Just look for Ponyta's, Alakazam's and Magcargo's entries, for instance.

actual scientific literature. The Galarian poser "professor" is a dark stain to the honorable profession of Pokémon Professor – and of paleontologists, of course. However, she is surprisingly appropriate for our times, being well in tune with all those "Fox News experts": flat-Earthers, climate change deniers, creationists, and anti-vaxxers. Dark times call for dark Pokémon NPCs, I suppose.

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About the author

Dr. **Rodrigo Salvador** is a paleontologist who studies snails, although he has dabbled a little in dinos and fossil birbs too. His long-time favorite Pokéfossil is none other than Lord Helix, despite the anatomical flaws in comparison with real ammonoids. Rodrigo was eager for the new fossils in *Sword & Shield* but ended up massively disappointed. On the bright side, at least the new horrible Pokéfossils served as a backdrop and excuse to write this article.

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Killer animals in films: reality vs fiction

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Among horror, drama, action, and sci-fi films, the subgenre of killer animals has been exploited since the very beginnings of cinema (*e.g.*, *The Sea Beast* from 1926, and *King Kong* from 1933; Fig. 1).

In the 1950's, a peak in movies about killer animals was spearheaded by *The Beast from 20,000 Fathoms* (1953) and *Gojira* (1954). Most of the films during this decade were about giant animals (Sánchez, 2007; De Fez, 2007).

Later, in the 1970's, the number of killer animal films grew incredibly after the successful *Jaws* (1975) was released, only this time the animals were not monstrous or abnormally big. Instead, they were "normal"

Figure 1. Movie posters of *The Sea Beast* (1926), an adaptation of Herman Melville's *Moby Dick*, and *King Kong* (1933). Sources: Wikipedia and Filmaffinity.com, respectively.

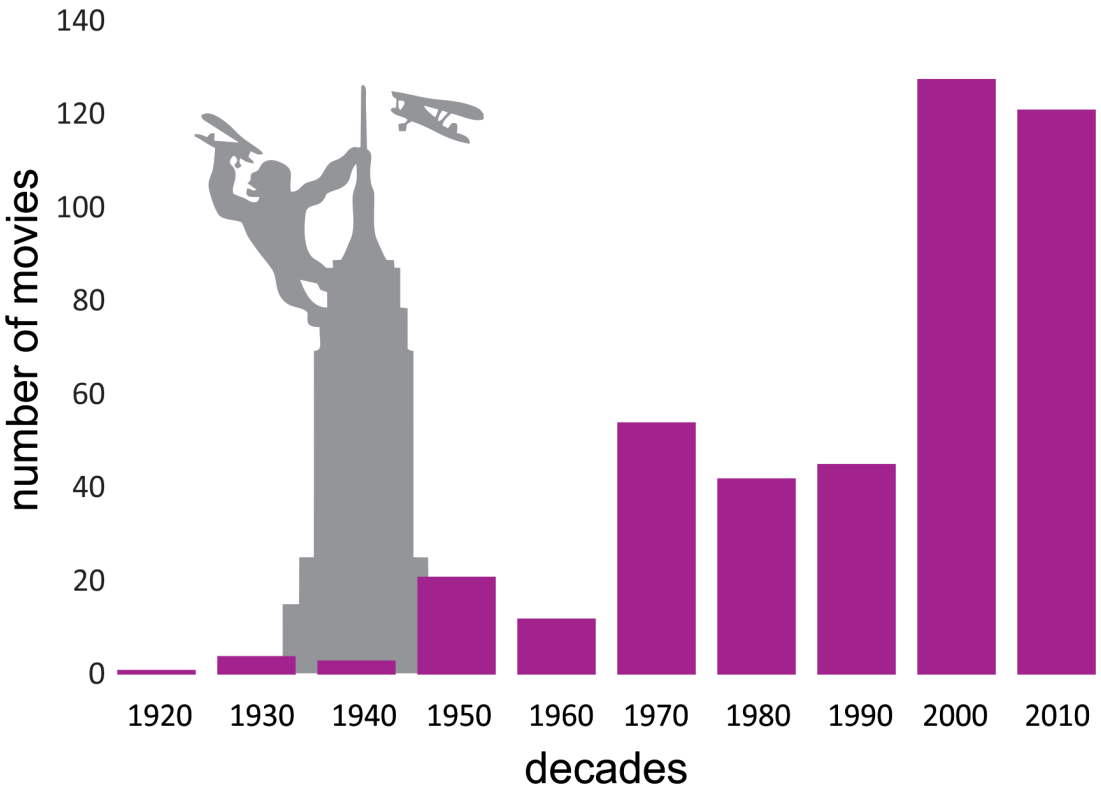

Figure 2. Graph showing the number of killer animal films per decade.

animals, representing a more real threat (De Fez, 2007), a trend that was already popular in the 1960's with films like Hitchcock's *The Birds* (1963).

With the use of CGI (Computer Generated Images) in more recent times, this subgenre increased exponentially. There were 190 killer animal movies released before the year 2000 (in nearly 100 years of cinema history) and more than 250 movies since (Fig. 2). This dramatic increase of killer animal films started with the influential *Jurassic Park* (1993).

Non-human animals constitute the cause of death of millions of people each year, by transmission of deadly diseases, venomous bites or violent attacks. However, are the animals as dangerous as depicted in films? Which are the animals that causes more human deaths each year, apart from humans ourselves? Are the deadliest animals the focus of horror films?

MATERIAL AND METHODS

A thorough search of horror/drama/action/sci-fi films with killer animals as the main antagonists was performed using the public online databases IMDb (https://www.imdb.com/) and Letterboxd (https://letterboxd.com/). The complete list of compiled films can be accessed at https://letterboxd.com/ghelhal/list/animal-attack/. Original movie titles are used herein, romanized when necessary (*e.g.*, the Japanese movie *Gojira* was released internationally as *Godzilla*).

The data was confronted with the number of human deaths per year caused by animals (Wikipedia, 2020). Many animals starring in horror movies do not represent real threats to humans and therefore, there are no available data regarding the number of human deaths per year to be included in the analysis.

RESULTS

Some animals have captivated the febrile minds of filmmakers in spite of the fact that they do not kill a large number of humans each year, as shown in Figure 3. That is the case for sharks (80 movies and 10 deaths per year), crocodiles (37 movies and 1,000 deaths per year), and spiders (18 movies and very few deaths each year, given that antivenoms are readily available; Diaz, 2004).

Other animals have been featured in several horror movies (Fig. 4), even though they do not represent a threat to humans (although some of them can kill people). They are: non-human primates (16 movies), dinosaurs (excluding birds; more than 15 movies and no confirmed human casualties due to lack of coexistence), cephalopods (over 10 movies), birds (11 movies), bees (12 movies), ants (9 movies), piranhas (8 movies), bears (8 movies and around 3 deaths each year), domestic cats (7 movies), pigs (6 movies), bats (6 movies), and wasps (5 movies).

On the other hand, some of the deadliest animals have been featured in very few movies or in no movies at all (Fig. 3). In this group we can mention mosquitoes (2 movies and 1 million deaths per year due to several diseases including malaria, yellow fever, and dengue), tsetse flies (2 movies about flies in general and 10,000 deaths per year due to tsetse disease), assassin bugs (no movies and 10,000 deaths due to Chagas disease), and freshwater snails (no movies and 10,000 deaths due to schistosomiasis).

Some of the taxa fairly represented in films (Fig. 3) are snakes (23 movies and 50,000 deaths per year), dogs (14 movies and 25,000 deaths per year due to rabies plus 15 from violent attacks), and scorpions

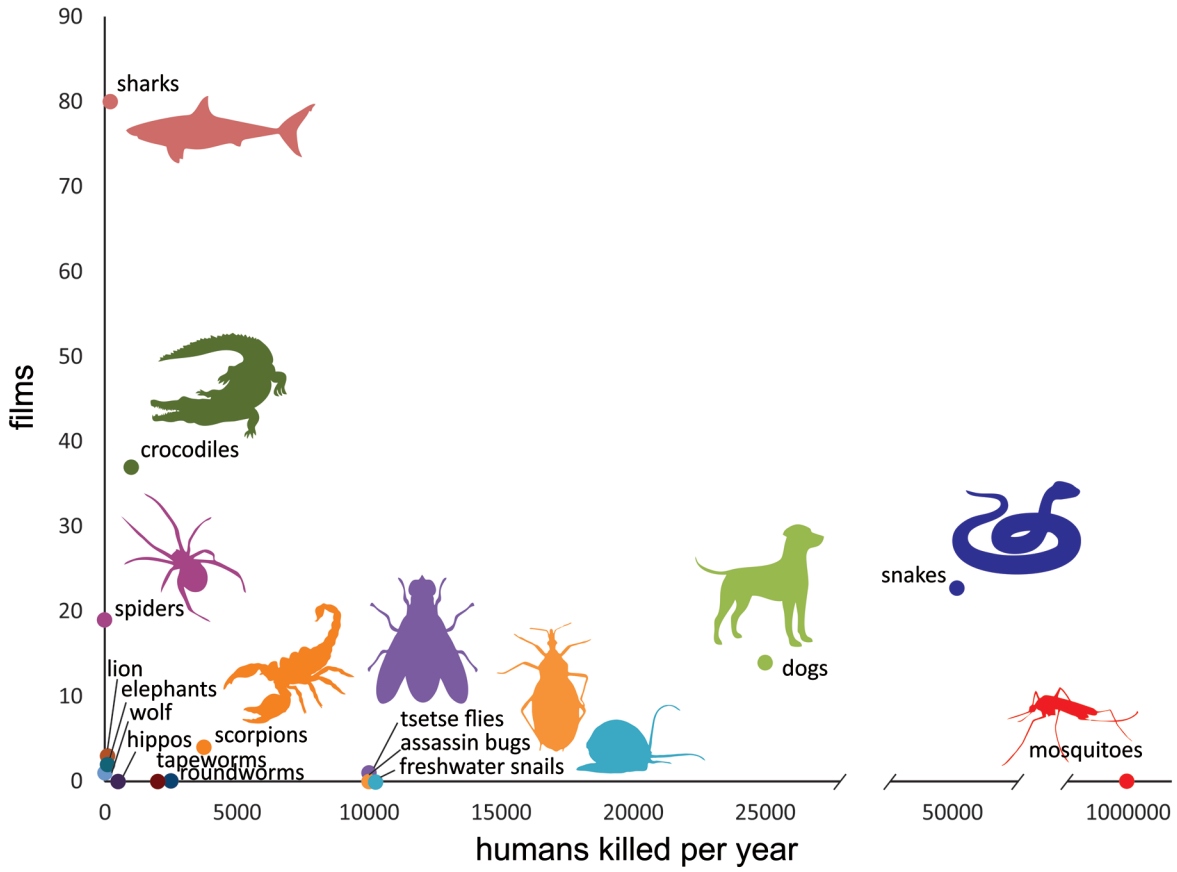

Figure 3. Graph showing the number of human deaths per year versus the number of films of selected animal group, of a total of 442 films. Note that the x axis is not to scale.

(5 movies and 3,250 deaths per year).

There are a few animals with bad reputations and considered natural pests, like cockroaches (4 movies) and locusts (3 movies). While no one has died due to a locust attack, it is a divine punishment in Biblical myths. Also, given that rats transmit several diseases (e.g., hantavirus, leptospirosis), the fear they inspire has resulted in at least 16 movies (Fig. 4).

Among the most bizarre animal choices for a horror movie are *The Tingler* (1959), about a velvet worm-like parasitic creature (Fig. 5), *Night of the Lepus* (1972), about mutated giant rabbits, and *Psycho Pike* (1992), about a large aggressive pike.

A special mention to the cross-subgenre of killer zombie animals, where we can find *Black Sheep* (2006), *Poultrygeist* (2006), *Zombeavers* (2014), *Zombie Shark* (2015), *Zoombies* (2016) and *Zoombies 2* (2019), among others.

CONCLUSION

A review of movies involving killer animals shows that the animals that causes thousands of human deaths each year do not inspire fear or concern in movies and hence, in the public. This may be in part reverted by educating about diseases transmitted by these animals and the real danger that some animals represent.

The negative image that other animals have in the eyes of the public can affect their survival as, for example, the killing of bats after the COVID-19 outbreak in early 2020 (Anonymous, 2020). To some degree, horror movies are responsible for the negative image of many animals.

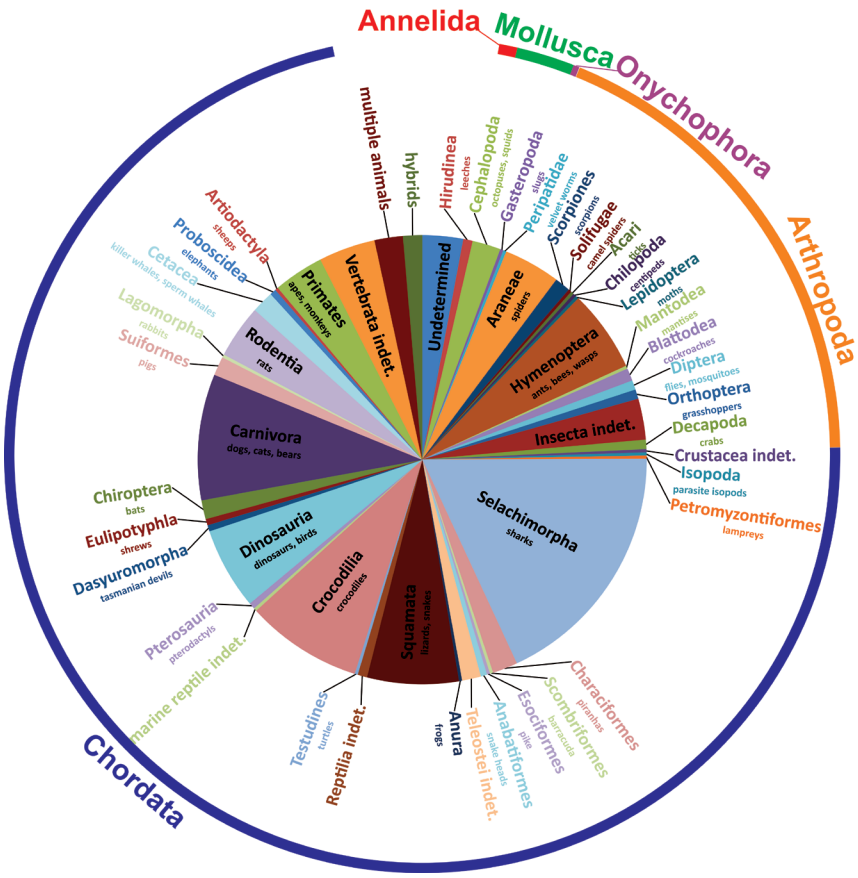

Figure 4. Pie chart showing the proportion of killer animal movies divided by major animal groups. Only the Phyla Annelida, Mollusca, Onychophora, Arthropoda, and Chordata are represented (out of circa 35).

Figure 5. Left: promotional still from the movie The Tingler (1959), starring Vincent Price. Right: photo of a velvet worm, Peripatus sp. Sources: Columbia Pictures and Wikipedia, respectively.

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FURTHER WATCHING

Here's a list of 15 classics to get a better understanding of killer animals in films.

- *King Kong* (1933, USA), directed by Merian C. Cooper and Ernest B. Schoedsack;
- *Creature from the Black Lagoon* (1954, USA), directed by Jack Arnold;
- *Gojira* (1954, Japan), directed by Inoshiro Honda (international title: *Godzilla*);
- *The Birds* (1963, USA), directed by Alfred Hitchcock;
- *Phase IV* (1974, UK/USA), directed by Saul Bass;
- *Jaws* (1975, USA), directed by Steven Spielberg;
- *Piranha* (1978, USA), directed by Joe Dante;
- *Prophecy* (1979, USA), directed by John Frankenheimer;
- *Cujo* (1983, USA), directed by Lewis Teague;
- *Razorback* (1984, Australia), directed by Russell Mulcahy;
- *Jurassic Park* (1993, USA), directed by Steven Spielberg;
- *Mimic* (1997, USA), directed by Guillermo del Toro;
- *Open Water* (2003, USA), directed by Chris Kentis;
- *Gwoemul* (2006, South Korea), directed by Bong Joon-ho (international title: *The Host*);
- *The Reef* (2010, Australia), directed by Andrew Traucki.

About the author

Dr. **Luciano L. Rasia** is a paleontologist working on the evolutionary biology of caviomorph rodents. He is an avid enthusiast of horror and science fiction cinema and literature.

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Svoboda 1945: life after World War II

Interview with Vít Šisler

Svoboda 1945[1] is a game in development by indie studio Charles Games (Prague, Czech Republic). It is scheduled for release later in 2020. In this game, you will live in a small town in the Czechoslovak-German border, right after World War II is over. The region is marked by the violence of the war and the instability after the Nazi troops retreated. The story of the game is told through interactive comics and mini-games, with real (and rare) film footage and cinematic-style interviews. The game, like its forebear *Attentat 1942*[2], was developed in close partnership with professional historians from the Institute of Contemporary History of the Czech Academy of Sciences.

To better understand the history behind *Svoboda 1945*, the Journal of Geek Studies interviewed Vít Šisler, lead designer at Charles Games. We learned a lot about the game and about Czech History too, so keep reading to find out more.

Q: *Svoboda 1945* is interesting in so many ways, so we'll start with the aspect that most got our attention. Your previous game, *Attentat 1942*, focused on the time during World War II and Nazi occupation,

[1] You can find it at https://www.svoboda1945.com/
[2] You can find it at http://attentat1942.com/

which one could argue it's the usual way to go for games (and movies etc.) dealing with the topic. *Svoboda 1945*, however, takes place after the war ended and the Nazi retreated from Czechoslovakia[3]. So how did this choice was made? What sparked the idea for this game?

A: From the start we wanted to have a series of games that is tied up with our national history and maps the second half of the 20th century. As in many other countries, the end of World War II didn't bring instant peace. In the case of Czechoslovakia, there was a mass expulsion of German-speaking citizens, which is still a matter of heated debates today. Also, the country started aligning itself with the Soviet Union and in 1948 turned into a totalitarian state after communist coup d'état. Post-war times are actually the source of many grudges, national traumas, unresolved personal and political conflicts. This is what we wanted to explore in *Svoboda 1945*. The echoes of war still reverberate through our game village, but on the backdrop, many other issues arise – can vengeance be justified? What memories should be kept alive? And at what cost? And what's it like to be confronted with moral ambiguity inside your own family?

As for the series – it allows us to capture how world events struck the lives of the individuals. We have recurring characters and players can see how they coped both with occupation and post-war reconciliation. It allows us to explore these topics much deeper.

Q: Like *Attentat 1942*, *Svoboda 1945* is a collaboration between Charles University and the Czech Academy of Sciences, between game developers and historians. How did you manage to pick the interest of historians to participate in a game? And how does this relationship work?

A: At the very beginning, we created an educational simulation for Czech history teachers within a grant project financed by the Czech Ministry of Culture. The historians agreed to participate in this project, particularly because they were interested in seeing the results of their research used beyond academia. Upon seeing we are tru-

[3] The country was split in 1938 following the Munich Agreement (a.k.a. Munich Betrayal) and largely incorporated into Nazi Germany. Its government, however, continued to operate in exile, known as the Provisional Government of Czechoslovakia. After the war, the country was re-established, except for the Subcarpathian Ruthenia territory, which became part of Soviet Ukraine.

ly devoted to the subject, convincing them that we should make a proper, public, international game wasn't that hard. But they didn't initially trust the idea and I guess for good reasons. Games are not exactly known for their historical accuracy and sensitivity. But gradually we found a way to work together which turned out to be inspiring in both ways. Our historians didn't only help us to be historically accurate, but they did write the stories, they became script writers, authors of the game and in the end game designers. I think they enjoyed working in a totally different way than they are used to and we definitely learned a lot outside of our area of expertise. We wrote a whole devblog[4] about it and we recommend everyone to try to get other than traditional game-oriented professionals involved. *Attentat 1942* or *Svoboda 1945* couldn't have happened without them. They kept our game development work within historically sensitive bounds.

Q: There are some games out there with a healthy dose of historical backgrounds, such as Ubisoft's *Valiant Hearts* and *Assassin's Creed* and, more recently, *Through the Darkest of Times* by Paintbucket Games. How do you approach History in *Svoboda 1945*?

A: Having a historical background in a game isn't the same as making a serious historical video game. From the onset we knew we wanted to make a game that not only uses history as a setting, but is about history. So not only we strive to be historically-accurate, meaning nailing the visuals etc. right, but we are showing the past from multiple perspectives, focusing on how ordinary people lived through the tumultuous times. More importantly, in our games we discuss how different people talk about the past, how history and memories are framed and reproduced. *Attentat 1942* and *Svoboda 1945* try to shed light on the past from an angle that is different to the succession-of-dates kind of approach. We want to see the human side of "big history", tackling topics that go very deep in the national and international psyche. Also, unlike other games, we don't let you play history. *Attentat 1942* takes place in 2001, and you are ret-

[4] See it here: https://www.gamasutra.com/blogs/OndrejTrhon/20200213/357817/When_history_gets_interactive_Attentat_1942_Svoboda_1945_and_historical_research.php

rospectively delving into memories of your relatives and other people you meet, but you can't change the past.

Q: Do you believe developers have a responsibility when representing history in their games? Should it be a priority over artistic freedom?

A: I don't think that there has to be an inherent conflict between responsibility and artistic freedom. You can create a fun and commercially successful game without necessarily stereotyping the past. Yet, it is important to know as a developer that video games are indeed capable of shaping our perception of the past, as any other media. We at Charles Games believe that we can create games that are serious and have capacity to touch players, make people reflect, and show them something important about the world.

Q: Let's get more into the gaming side now. In simple terms, *Svoboda 1945*[5] is a dialog-based adventure game, right? So, what exactly is the players' goal in it?

A: It is an adventure game with a lot of FMV[6] sequences, interactive comics, and playable memories, which are basically short games, like the one in which you develop photographs one of the characters took during post-war expulsions in a dark room. The year is 2001, you arrive in the village as a researcher who should decide if a local school could be demolished. The village is in the Czechoslovak-German borderlands and its inhabitants experienced occupation, horrors of the Holocaust, liberation, post-war cruelties, as well as forced collectivisation after the communist putsch, all of it. So, you find yourself in a very contentious place and then you find out that your own family was also involved. So a rather administrative task turns into a personal quest. Traumas run deep…

Q: Does the game follow the story of a single character then?

A: We have a protagonist, the researcher, but you meet a lot of people along the way. Formerly expelled German woman, returning to the village for the first time since childhood. Local chronicleman whose

[5] 'Svoboda', by the way, means 'freedom'.
[6] FMV is short for 'full motion video'

friend died during liberation. Holocaust survivor. Son of a local communist official turned successful businessman. Many others.

Q: How faithfully does the game follow real-life events?

A: The village in *Svoboda 1945* is fictional, because of ethical reasons. As is the case with *Attentat 1942*, all our main characters are constructed, but based on historical research and existing memories. We reference a lot of actual events in the game, we also have an encyclopedia where you can read all about them. Everything that happens in the game generally happened to somebody, somewhere after 1945, but perhaps a little differently, as we also need some space for game design and script writing. Yet, we try to be as truthful as possible. Every single character, utterance, or object in the game was written or approved by professional historians.

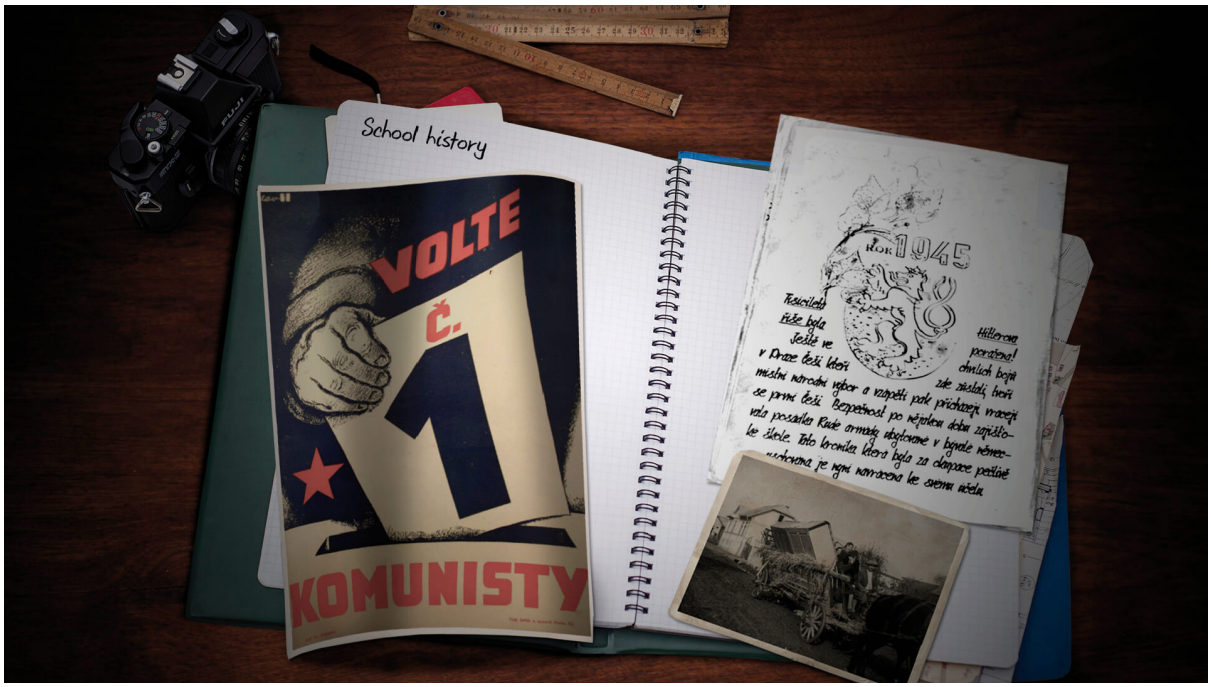
Q: Can we expect authentic historic footage and interviews in *Svoboda 1945* like we've seen in *Attentat 1942*?

A: Yes, it's there. Historical footage is as important as our comics and full motion videos. They all serve storytelling purposes. While we use historical footage to reference real historical events, black and white comics depict the constructed past of our protagonists. By doing this we want to make the constructedness of our characters transparent, rather than obfuscating it.

Q: Besides those mentioned above, what other kind of source material has made into the game?

A: Our historians went through hundreds of oral testimonies, primary and secondary documents, and academic literature. They also visited local archives in the area our game takes place that provided us with tons of documents and photographs. The rare historical footage comes from the Czech National Film Archive.

Q: Czechoslovak history is not a usual topic in history classes and textbooks[7] for



[7] The German annexation preceding WWII and the Prague Spring are possibly the only times most people hear about the country's history in more detail.

most people out there. Do you hope your players will learn something by playing *Svoboda 1945*?

A: The story we're telling might sound particular, but I believe it isn't. For starters, other states have similar experiences. But more importantly, it's a general story. The questions about justice, about how to live after the horrors of war, how to reconcile with your family history… there are larger things at play. So yes, you will learn things about specifically Czechoslovak and central European situation, but also a lot about human nature generally. And a space to reflect on all that.

Q: So, if you pick the interest of a player about this historical period, could you recommend them some references about it? (Books, documentaries, articles, etc.)

A: Talking about books, Benjamin Frommer's *National Cleansing: Retribution against Nazi Collaborators in Postwar Czechoslovakia* is probably a good start for English speaking players, as well as Kevin McDermott's *Communist Czechoslovakia 1945–89: A Political and Social History*. For movies, I highly recommend *Adelheid*, a František Vláčil's masterpiece about the relationship between a Czech man and a German woman in postwar Czechoslovakia, and *All My Compatriots*, a legendary 1968 film directed by Vojtěch Jasný about a small village torn by the communist collectivisation.

Q: Is there any takeaway message you'd like the players to get from *Svoboda 1945*?

A: History often seems like something distant and given, yet it is our everyday decisions that create it. The decisions we make now can haunt us for decades. Peace and democracy are fragile and can't be taken for granted. *Svoboda 1945* ends right after the establishment of a totalitarian regime that lasted for decades. We should be wary of how easily we can lose freedom when it looks like it's regained for good.

About the team

Charles Games is the studio behind the award-winning game *Attentat 1942*. It consists of scholars and students from Charles University as well as independent artists. They focus on narrative games in unique settings and enjoy coming up with innovative ways to explore serious themes. They're based in Prague and are currently developing a new historical game *Svoboda 1945*, in collaboration with historians from the Czech Academy of Sciences.

Dr. **Vít Šisler** is a lead game designer of *Attentat 1942* and *Svoboda 1945*. He is a founding member of Charles Games and an assistant professor of new media studies at Charles University.

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What's your favourite Pokémon? Pocket monster popularity reflects interest in real-world Biology

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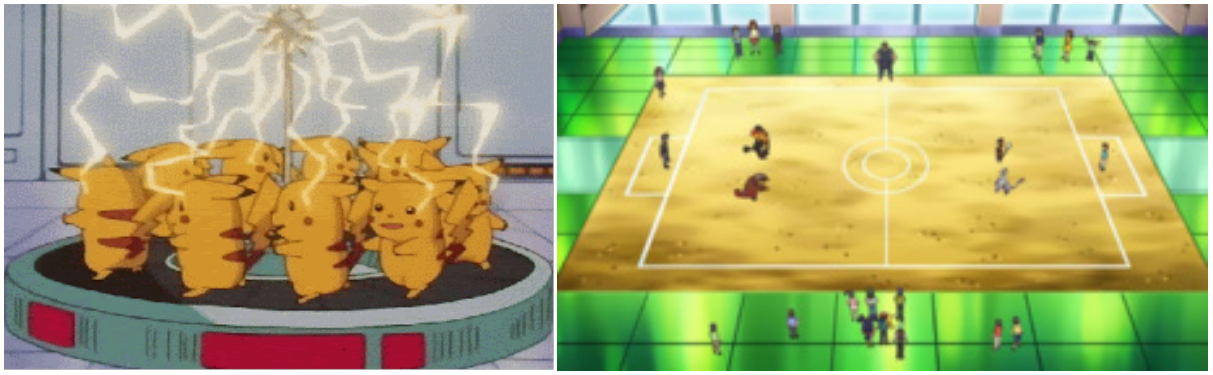
Tell me what Pokémon you like, and I will tell you who you are.

Each person is different and has different tastes, and within all the diversity of *Pokémon*, everyone, independent of gender, age and degree of involvement with the games, can find one Pokémon that is the best fit for them. Everyone has a favourite Pokémon, and every Pokémon is someone's favourite. But our choices can be influenced by the real word and can tell a lot about the human society and culture.

Everyone who plays or watch Pokémon have dreamt about having its own pocket monster, as a pet, a friend, or a partner in crime. It says a lot about the ways humans see animals and biodiversity in general (Ethnozoology). Depending on culture, animals can be venerated or respected, or, on the contrary, exploited, not considered as living beings, and exterminated. This attitude varies not only between cultures but also within the same culture through time (Tapper, 1988). Many cultures' myths or folklore have a close relation with animals, having developed over time by interaction with the local fauna.

However, on a larger scale, cultural point of views can affect conservation and even the evolution of some species. In popular opinion, the animals who most "deserve to be saved" are the cutest, more beautiful or more famous ones ('willingness-to-pay'; Colléony et al., 2016); charismatic species that serve as symbols and rallying points to stimulate conservation awareness and action (also known as umbrella species or flagship species). It has been shown that perception and affinity ratings for animal species primarily depend on the criteria 'appearance', 'usefulness/harmfulness', and 'rareness'. For instance, pets have been artificially selected to be cute for our own personal luxury, despite the high risks for their health and survival (Serpell, 2003). Still, human perception of animals has several impacts on biodiversity and the environment in general. The international, legal and illegal, trade of wildlife (for domestic purpose, entertainment, exploitation for food, or alleged medicinal purposes) is a major business, critically affecting the preservation of some species (Broad et al., 2014). With a value between $7 billion and $23 billion each year, illegal wildlife trafficking is the fourth most lucrative global crime after drugs, human trafficking, and weapons (AWF, 2015).

Humans have always attempted to understand animals, to enslave them, and to capture their strength and power (Holley, 2009). In the *Pokémon* world, the same problematics are approached. On the one hand, Pokémon can be captured in the wild to be used as weapons in combat for power, glory, and money, or just for the sake of collecting them. On the other hand, they can be real friends and companions, and may even be part of society by working on medical services or security. The relationship



In the *Pokémon* world, Pokémon can be used for their special powers in everyday life or during combat. The entire society is built around them and the economy is based on their exploitation.

between humans and Pokémon is, naturally, very similar to that between humans and animals. In the games, the place of Pokémon and the responsibility of humans to them are also questioned by the villainous teams (typically presented as large organizations) that are the antagonists in the *Pokémon* world. Those can be understood as images of real-world mafia, poachers, and even ecoterrorism groups. As every element from pop culture, Pokémon can teach us about our own civilization and how our society, in turn, influences pop culture and its related industries.

Most Pokémon are based on real animals or mythical creatures (mainly from Japan); some were based on plants, fungi, minerals, objects, or have weird origins (scientific experiments, aliens, or macabre materialization). But the general tastes of people when choosing their favourite Pokémon might follow a common pattern, and one that can teach us about our culture. We can suppose that favourites are also chosen according to their popularity outside the *Pokémon* games/anime and to their similarity with something already familiar. For example, choice can be biased due to their resemblance to an already popular animal in our world (cats and dogs) or our imaginations (monsters, dinosaurs and dragons). Pokémon can also inspire feelings of power or protection, which affect their popularity in their fictional world; supposing that *Pokémon* fans would like to have a Pokémon with them, the favourite is chosen because of their strength or reassuring appearance (cute and fluffy). On the contrary, less popular Pokémon would be the ones that inspire weakness and disinterest for people. Of course, we also have to take into account the emotional bias in preferences that the original impact of the *Pokémon* franchise had on people, meaning that we expect to find more favourites from the first generation (Gen I). Finally, we expect to have an anthropomorphic bias in choice: Pokémon who look more human-like (bipedal, use objects or "clothes", have more empathic faces, etc.) might be more often selected as favourites.

METHODS

Data

The data used here are the results of an online survey asking people which was their favourite Pokémon to test the hypothesis "Every Pokémon is someone's favourite". 809 Pokémon from Generations I through VII were included (alternate forms are not listed separately). The survey[1] was anonymous to avoid bias of selection and limited to one response per participant. People were asked to pick one or several favourite Pokémon out of a list of 20 Pokémon, re-

[1] By Butterfree/Dragonfree/antialiasis, 2018. Still available at https://www.dragonflycave.com/favorite.html

peating this process for several rounds until only a few monsters remained, from which the overall favourite could be elected.

After 52,725 responses (average 65 votes per Pokémon), the results[2] were analysed and some patterns could be distinguished. We have to take into account that the survey was conducted without control for gender, age or cultural background of respondents. It was divulged online through a specialised website in English, which excludes non-English speakers (country bias) and some non-aficionado people (possible age and gender ratio bias). These can bring a lot a bias in the results and confound interpretation. However, the number of responses was very high overall, enough to assume powerful statistical tests. Even if interpretations have to be taken with prudence, we can at least make several useful assumptions and raise questions about the perception of Pokémon biodiversity.

Classification

All the Pokémon have been classified according to the "species" that inspired it. Most information come from Bulbapedia (https://bulbapedia.bulbagarden.net/), according to the English or Japanese name or interpretation of the community who manages the website. Because some Pokémon have abstract inspirations, are mythological, or a mixture of different species, we tried to be as precise as possible; we acknowledge that many mistakes or misinterpretations are present in the dataset. The Pokémon were then classified in the following categories according to their inspirations: Humanoid, Object, Ghost, Mineral, general Biology, Vegetal, Fungi, and Animal. The latter was divided into general clades of animals: Amphibian, Arthropod, Bird, Dinosaur, Fish, Invertebrate, Reptile, and Mammal. "Invertebrate" is not a natural clade, but was used to represent cnidarians (jellyfish, corals), echinoderms (starfishes, sea cucumbers) and molluscs. Crocodilians were included in Reptile, even if phylogenetically they are closer to dinosaurs and birds. Finally, Dragon is considered as an extra distinct clade within Animals, because of their mythological origin and prevalence in *Pokémon*. We did not consider the Type of each Pokémon (Fire, Ground, Psychic, Bug, etc.) in the analysis.

RESULTS AND DISCUSSION

Generation bias

As expected, we have a bias of votes for Pokémon from the first generations. The distribution of votes decreases with generations (Table 1, Fig. 1). Because there are not the same number of Pokémon in each generation, we have to use the average number of votes per generation and use an ANOVA (Kruskall-Wallis test[3]) to compare the effect of generation on the number of votes. The test indicates that there are significant differences between groups of generations (Kruskal-Wallis chi-squared = 146.76, df = 6, p-value < 2.2e-16). To investigate further the differences among groups, we used a pairwise Wilcoxon[4] test between generations (only the test with Gen I is shown in Table 1). The differences among groups indicate that for further analyses, the generation range can influence the results.

The number of votes is higher for Gen I and decreases after it. In Figure 1, we can also see that the highest number of votes is shared between the first generations. This bias can be explained because the first generations have the benefit of coming first, having the creativity initiative and receiv-

[2] The final results can be found at https://www.reddit.com/r/Pokémon/comments/c0w4s0/favourite_pok%C3%A9mon_survey_results/

[3] A non-parametric-test (the data do not follow a normal/Gaussian distribution) to analyse the difference of variance (ANOVA) among groups.

[4] A non-parametric-test to assess whether the mean of two groups differ.

ing most of the popularity from the start. Because the survey is anonymous, we do not know the age of respondents to figure out if they are "Gen I kids", but we can suppose that in most cases, people discovered *Pokémon* during the first generations and stopped being involved with the franchise with time, missing out the last generations.

Table 1. Number of votes per generation and average of votes per Pokémon in that generation (± standard deviation from the mean). The p-value indicates the value of the test in comparison to Gen I. Tests are significant when p-value is under the threshold of 0.05 (*: significant; **: highly significant).

Generation	Nr votes	Mean ±SD	p-value
I	18289	121.12 ±184.65	–
II	9115	91.15 ±125.20	p=0.70
III	9469	70.14 ±119.62	p<0.001 **
IV	7622	70.57 ±107.06	p=0.0027 *
V	4300	27.74 ±41.74	p<0.001 **
VI	2154	29.92 ±46.53	p<0.001 **
VII	1776	20.18 ±34.95	p<0.001 **

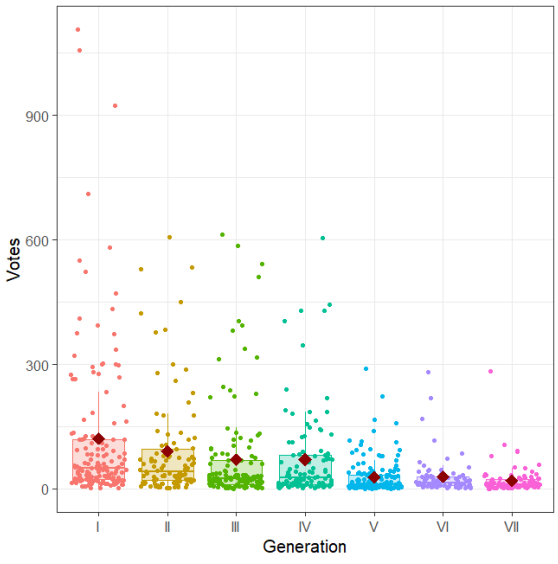


Figure 1. Box plot of the distribution of number of votes (points) of every Pokémon in each generation, and average of votes (red diamond) per generation.

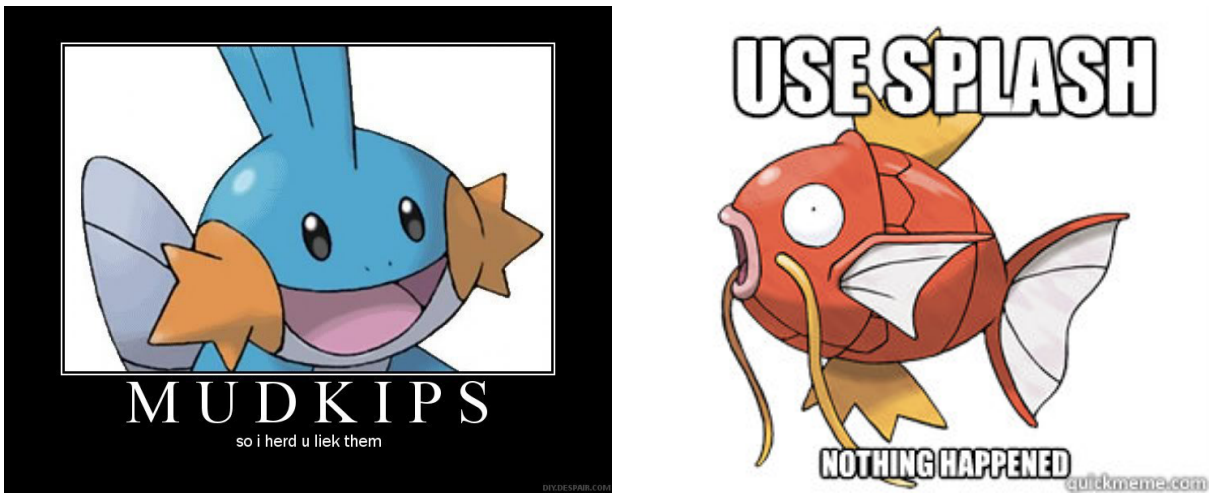
Starter bias

The emotional side is also influencing the vote. Among the first 20 most voted Pokémon, 7 are starters and concentrate the majority of votes (Table 2). The average number of votes for the starters are significantly different from the Pokémon that have "no advantage" (Wilcoxon test, p-value = 7.6e-8). This means that most of the favourite Pokémon are actually the most used monsters in the games, which makes gamers feel closer to them. However, the starters have been purposefully chosen by game developers to be popular due to their resemblance to popular animals, real or mythological. For instance, several starters are reptiles/amphibians with a dinosaurian or a dragon-like design (around 47%); the rest are mammals (39%) and birds (14%). Because this clearly doesn't represent real animal biodiversity (where well over 90% are invertebrates) and also creates a large bias in the results, the starters were removed from the rest of the analyses.

Table 2 also shows that among the top 20 favourite Pokémon, nine are from Gen I. All the rest are from Gen II to IV, confirming that we have to take into account the generation bias in the analyses. Among the favourite Pokémon, some are also really popular on the Internet for diverse reasons (typically as memes) and overrepresented outside the Pokémon core franchise. This extra popularity has affected randomly the number of votes (Wilcoxon test, p-value = 5.6e-4), but is not directly linked to their species of inspiration or origin. Consequently, these factors will not be taken into account for the interpretation. Another advantage that could cause a boost in popularity is being a legendary or mythical Pokémon, or otherwise rare and unique. However, those Pokémon do not have a significantly different number of votes compared to "normal" monsters; thus, their legendary/mythical status was likewise not taken into account.

Table 2. Top 20 most favourite Pokémon according to total number of votes; also shown is their Generation, clade (the group to which the Pokémon belongs, see text), the "species" to which they can be associated with, their origin, and any feature that might have given them and advantage in being chosen (e.g., being a starter, legendary, etc.).

Rank	Pokémon	Nr votes	Generation	Clade	"Species"	Origin	Advantage
1	Charizard	1107	I	Dragon	Dragon	Fantastic	Starter
2	Gengar	1056	I	Ghost	Ghost	Yōkai	
3	Arcanine	923	I	Mammal	Dog	Pet/Fantastic	
4	Bulbasaur	710	I	Amphibian	Toad		Starter
5	Blaziken	613	III	Bird/Humanoid	Rooster	Domestic	Starter
6	Umbreon	607	II	Mammal	Fennec	Pet	
7	Lucario	604	IV	Humanoid	Canine	Pet	Meme
8	Gardevoir	585	III	Humanoid	Human		Meme
9	Eevee	581	I	Mammal	Fennec	Pet	Meme
10	Dragonite	551	I	Dragon	Dragon	Fantastic	
11	Absol	542	III	Mammal	Feline	Yōkai	
12	Typhlosion	534	II	Mammal	Hedgehog		Starter
13	Ampharos	529	II	Mammal	Sheep/Dragon	Domestic	
14	Squirtle	523	I	Reptile	Turtle		Starter
15	Flygon	510	III	Dragon	Dragon		
16	Ninetales	471	I	Mammal	Fox	Yōkai	
17	Tyranitar	451	II	Dinosaur	T-rex	Kaiju	
18	Infernape	443	IV	Mammal	Ape		Starter
19	Snorlax	433	I	Mammal	Bear		Meme
20	Torterra	430	IV	Reptile	Tortoise	Fantastic	Starter



Two examples of Pokémon memes, based on Mudkip (rank 24) and Magikarp (rank 107).

Favourite Pokémon

Only Pokémon with animal and human inspiration have been include in the analyses. This excludes Pokémon based on objects (8%), plants (6%), or minerals (3%), as well as some ghosts (3%). The popularity of each group of real-world animals (classified as clades) reflects the popularity of Pokémon (Fig. 2).

However, to go further in the interpretation, we have to take into account the generations; as we have seen earlier, they influenced the results. Moreover, not all clades are well represented in all generations, that is, the proportion of Pokémon by clade vary a lot among generations. To compare popularity of Pokémon according their animal clade, we have to take these factors into account along the number of votes (Fig. 3).

The average of votes per clade was thus corrected according to the generation: by dividing the average votes per clade by the weight of each generation, we obtained a ratio of votes by clade (Table 3, Fig. 3). If we compare the ratio of votes (corrected for generation; Fig. 4, Table 2) with the mean number of votes per clade (Fig. 2, Table 4), we can see that general patterns of favourites are also conserved (Table 3).

Table 3. Number of Pokémon and number of votes, mean votes (±SD) and ratio (±SD) per clade.

Clade	Nr Pokémon	Nr votes	Mean votes ±SD	Ratio votes ±SD
Amphibian	15	750	50.00 ±39.44	0.71 ±0.37
Arthropod	81	3302	40.77 ±77.20	0.75 ±0.58
Bird	52	2347	45.13 ±61.08	0.56 ±0.19
Dinosaur	34	2879	84.68 ±124.19	1.22 ±0.55
Dragon	27	2927	108.41 ±142.87	1.67 ±0.73
Fish	34	1103	32.44 ±59.4	0.43 ±0.14
Humanoid	81	4917	60.70 ±111.83	0.92 ±0.48
Invertebrate	34	830	24.41 ±21.76	0.54 ±0.39
Mammal	194	14249	73.45 ±126.27	1.01 ±0.23
Reptile	17	927	54.53 ±59.57	0.84 ±0.73

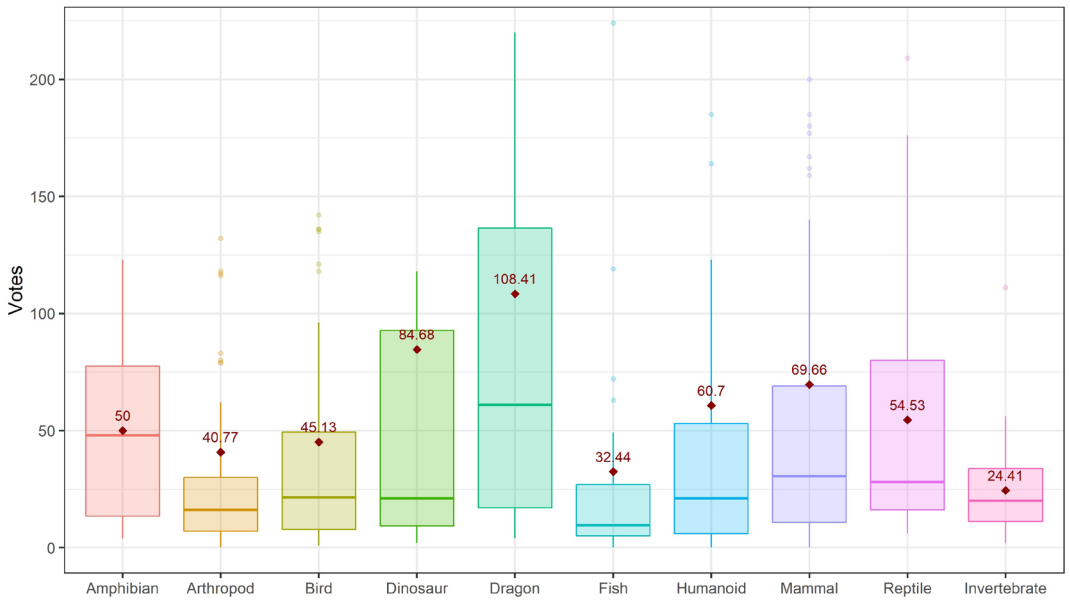


Figure 2. Box-plot of the distribution of the number of votes (points) of every Pokémon and average of votes (red spot) per clades of animal species. The outlier points (>220 votes) are not all represented here. Starters were excluded from this analysis.

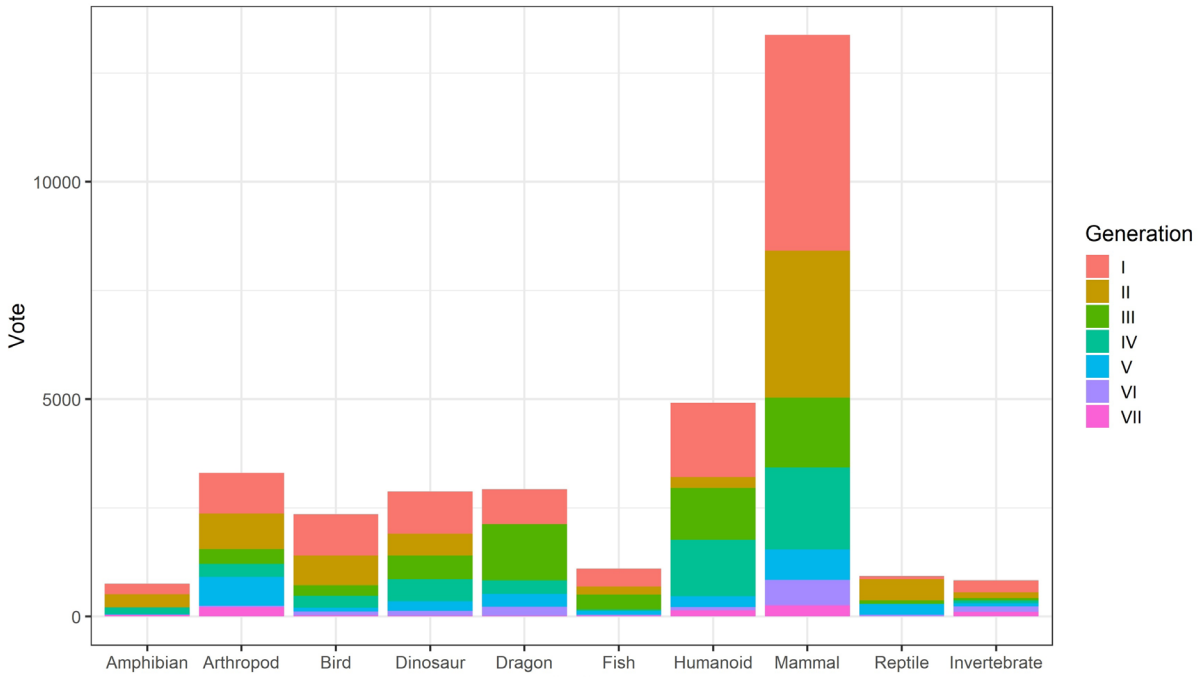


Figure 3. Cumulative histogram of the number of votes per clade according to generation. Starters were excluded from this analysis.

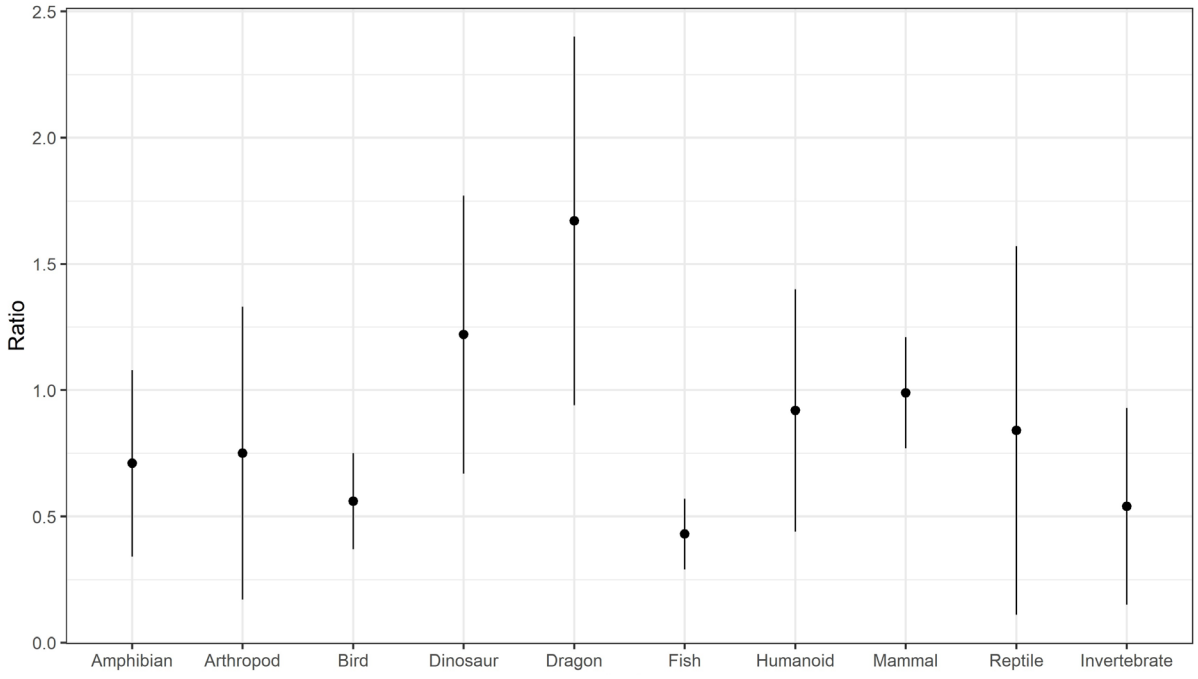


Figure 4. Average votes corrected for the weight of generation (ratio of votes ±SD) per clade.

Dragon and dinosaurs are the most favourite. This is not very surprising, though, because both are very similar in several aspects, inspiring fear and power, an important criterion in *Pokémon*. Dragons are the favourite category of Pokémon, underlined by THE most popular one, Charizard (Table 2). Dragons are mythical creatures and most dragon Pokémon are legendary or otherwise rare and among the most powerful monsters in the games, which could have influenced the number of votes. Dragon-like creatures are present in many cultures worldwide and are popular motifs (Baker, 2012), and the dragon Pokémon popularity simply follows suit. Dinosaurs have a mysterious aura and stimulate the imagination of children, being widely used in pop culture and as a marketing tool (Thomson, 2005). *Pokémon*, having been created in 1996, followed the world success of the cult dinosaur-movie *Jurassic Park*, so it is not surprising that many monsters have a dinosaurian inspiration.

Three of the most popular Pokémon, Dragonite (rank 10), Charizard (rank 1), and Tyranitar (rank 17), have a design inspired by dragons and dinosaurs.

Following the success of dinosaur-like Pokémon, reptiles and amphibians also obtained a high popularity score, placing before birds. This is quite surprising because birdwatching (or birding) is a popular hobby by all around the world (Cordell & Hebert, 2002), whereas interest in herpetology (the study of reptile and amphibians) is less common. Real-world birds are, on average, more appreciated than reptiles and amphibians (Schlegel & Rupf, 2009) and stimulate more curiosity and affinity (Zimihorski et al., 2013).

Despite the appearance, birds are actually dinosaurs. Braviary (rank 317) is based on the bald eagle, while Doduo (rank 637) is a two-head bird inspired by the Australian emu. The common pigeon has his own Pokémon, Pidove (rank 637), whereas Pikipec (rank 746) is inspired by a woodpecker (here a pileated woodpecker).

However, the number of bird Pokémon (52) relative to reptiles (17) and amphibians (15) can influence the design conception and their success. Birds represent a large amount of diversity, from the smallest and cutest birbs to the largest and impressive ones (the latter usually represented as legendary Pokémon). The success of bird Pokémon depends mainly on what particular species they represent and their own perceived reputation, which can unbalance the ratio of votes.

Reptiles are easily identifiable and fascinating for many people; despite the fear and danger they might inspire, they can be appreciated differently depending on cultural background. The notable abilities of reptiles (e.g., longevity, toxicity, movement) make them symbolic animals, often used in myths. The similitude with dragons is thus easily achieved. We also have to take into account that crocodiles are included here in the Reptile category despite their phylogenetic separation, but this did not change significantly the results. Crocodiles are biologically more closely related to dinosaurs, and viewed as an iconic, marketable species and a tourist attraction in many places, despite the fear and danger they might inspire.

Starter Pokémon used iconic reptiles as inspiration: Treecko (rank 95) is a green gecko and Squirtle (rank 14), an aquatic turtle (distinct from the terrestrial tortoises, such as starter Turtwig, rank 67).

Some species are often confused with the reptile group. Totodile (rank 42), as a crocodilian species, is genetically closer to dinosaurs and birds. Salamanders are also often mistaken with lizards, but are actually amphibians; some of the traits are clear, like the long tongue, naked skin and the digit extension in males for copulation present in Lickitung (rank 222).

There are more mixed feelings towards amphibians. Generally, the amphibian group is not the most popular, being mostly associated with negative reactions and representations. However, some iconic species in these groups (like tree frogs and newts) can receive a positive response from the public and thus, reverse the situation. Feelings of appreciation or disgust are difficult to compare between different cultural groups and may explain the large difference of success found between animal categories (Schlegel & Rupf, 2009). Amphibians are very popular in Japan and overall in Asia. Because of their ability to change their form, colonize different habitats, and come back to their birth place, they are an icon for travellers and thus very symbolic in shōnen and JRPGs, including *Pokémon*. That's also the reason why the first Pokémon in the Pokédex and starter in the game[5] is a toad, Bulbasaur[6]. However, amphibians are the most endangered vertebrates (Hoffman et

[5] *Pokémon Green*, from 1996, never made to the West, though we got the *LeafGreen* remake of 2004.

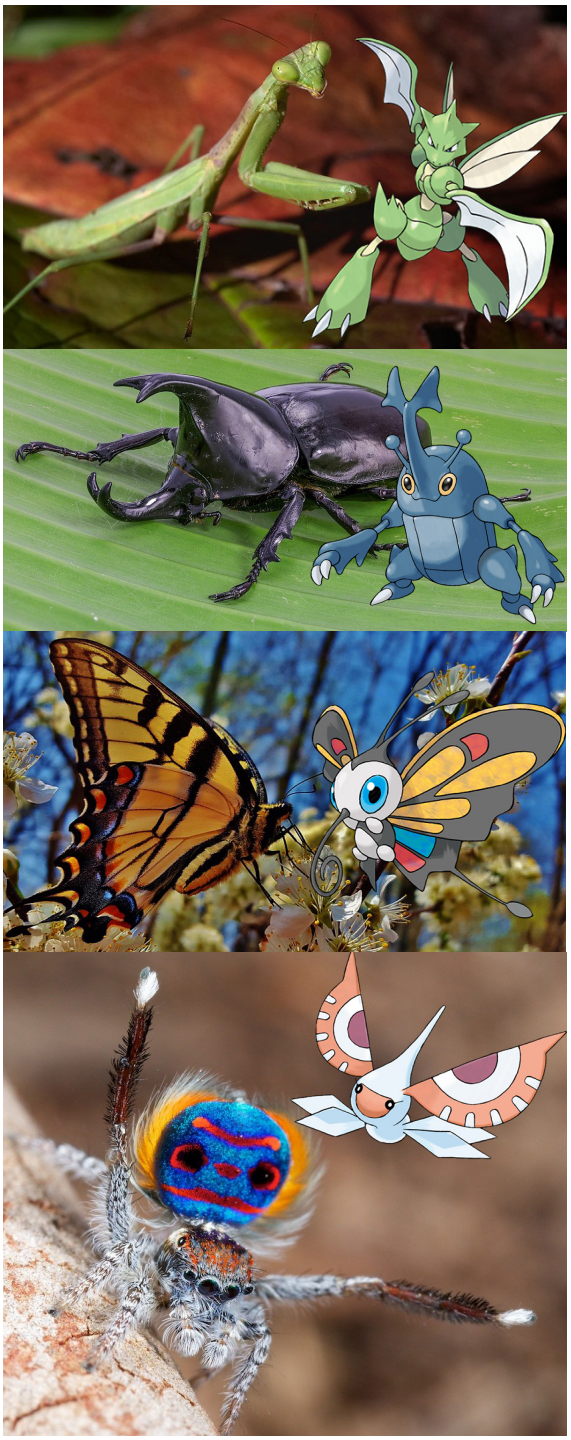
[6] The '-saur' suffix comes from the scientific name of many species, such as *Tyrannosaurus*. It comes from the Greek and means 'lizard' or 'reptile' and has been applied wrongly in both Biology (like most dinosaurs and the whale *Basilosaurus*) and Pokémon.

al., 2010) on our planet and most people are ignorant of this fact; amphibians' pervasive representation overshadows the threats they face (Biega et al., 2017).

The popular tree frog is represented by Politoed (rank 179), one of the final evolutions of the tadpole Pokémon Poliwag (rank 344), which conserved the spiral symbol (the intestine, visible by transparency in some tadpoles). Mudkip (rank 24) and his final form Swampert (rank 29), even if nominally inspired from the amphibious fish goby, got its crest and gill design from newts.

Ambiguous Pokémon

Attitudes to insects, crustaceans and arachnids are ambivalent. Arthropod Pokémon can be popular but at the same time, the most hated (Fig. 4, Table 4). This reflects well what's observed in our world, where there is in general low affinity for insects (Kellert, 1993). The high rate of success of some insect Pokémon is due to some iconic monsters (Scyther, Scizor, Heracross, Volcarona), which explains the difference in the distribution of the votes for this clade (Fig. 2) and the mean ratio of votes. Bug Pokémon are among the first encountered in the games and thus, also generally the weakest and most abundant (Prado & Almeida, 2017; Kittel, 2018), which unbalanced the popularity of other arthropod Pokémon. Pupae (cocoons) are particularly uninteresting and difficult to empathise with, which can explain the few (or zero) votes of some of them (Table 4).



The most popular insect Pokémon, Scyther (rank 27) and Heracross (rank 50), respectively represent a mantis and the Japanese rhinoceros beetle, famous for their combativeness. On the contrary, Beautifly (rank 770) and Masquerain (rank 397), probably inspired respectively by the tiger swallowtail and the coastal peacock spider, are not so popular despite their coloration and interest of the species in our world.

Table 4. The least favourite Pokémon. Only those with 0 or 1 vote are listed, alongside their respective evolutions and/or pre-evolutions when applicable.

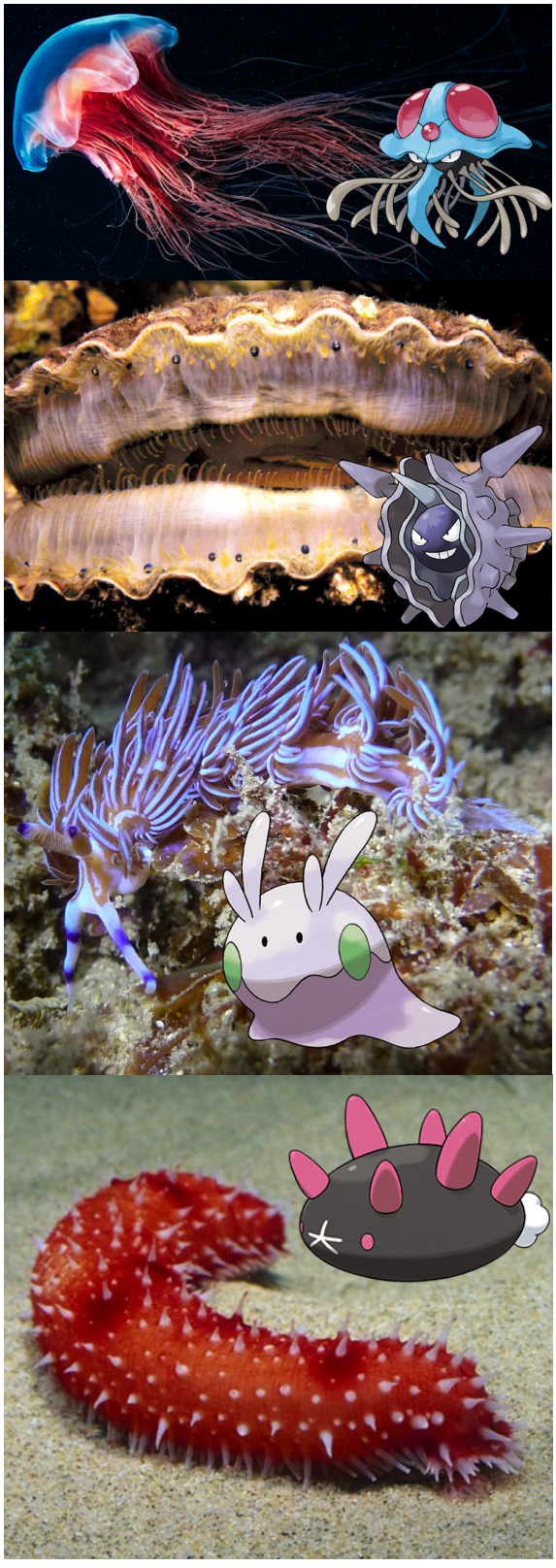
Rank	Pokémon	Nr votes	Generation	Clade	"Species"
242	Eelektross	49	V	Fish	Lamprey
489	Gothitelle	16	V	Humanoid	Gothic lolita
539	Wurmple	12	III	Arthropod	Caterpillar
573	Toucannon	10	VII	Bird	Toucan
660	Tynamo	6	V	Fish	Anchovy
687	Dustox	5	III	Arthropod	Moth
687	Gothorita	5	V	Humanoid	Gothic lolita
722	Gumshoos	4	VII	Mammal	Mongoose
722	Watchog	4	V	Mammal	Meerkat
746	Pikipek	3	VII	Bird	Woodpecker
770	Cascoon	2	III	Arthropod	Cocoon
770	Beautifly	2	III	Arthropod	Buterfly
798	Patrat	1	V	Mammal	Chimpmunk
798	Baltoy	1	III	Object	Status
798	Skorupi	1	IV	Arachnid	Scorpion
798	Sewaddle	1	V	Arthropod	Larvae
798	Alomomola	1	V	Fish	Sunfish
798	Trumbeak	1	VII	Bird	Woodpecker
798	Cosmoem	1	VII	Mineral	Cosmos
798	Exeggcute	1	I	Vegetal	Egg
806	Silcoon	0	III	Arthropod	Cocoon
806	Eelektrik	0	V	Fish	Lamprey
806	Gothita	0	V	Humanoid	Gothic lolita
806	Yungoos	0	VII	Mammal	Mongoose

Insects and arachnids (spiders and scorpions), besides not being very popular with the general public, are also a main source of phobias in western societies, and associated with negative stimuli; even while butterflies receive more attention than the rest by aesthetic reasons (Barua et al., 2012). This is manifested by the low value delegated to them by conservation measures, despite thousands of species being endangered and populations drastically declining (Simmons et al., 2019). At the same time, insects have considerable significance for certain cultures, such as the Chinese cricket culture (Jin & Yen, 1998) and the aesthetic appreciation for insects in Japan (Hogue, 1987). It is common to find amateur entomologists and insect collectors around the world; it is a popular hobby in Japan and the creator of *Pokémon* himself, Satoshi Tajiri, had the idea for the games due to his own passion for collecting insects.

Fish are an unpopular clade, considered very often as boring animals with limited cognitive abilities, or just plain ugly and disgusting. Except for the colourful tropical fish and seahorses, alongside those animals perceived as dangerous in public imagination (sharks, piranhas), most fishes are just seen as food despite their large biodiversity, which is well reflected in Pokémon (Mendes et al., 2017). Among the unpopular Pokémon (Table 4), we can find some based on common prey (Tynamo, anchovy) or parasitic (Eelektrik, lamprey) fish, with an off-putting appearance. The difficulty to observe them and the large differences of hab-

itat and morphology between humans and fishes contribute to misunderstand their behaviour and the difficulty to feel empathy for them.

Fish present a large diversity of coloration, form and habitat. Eelektrik (rank 806), a lamprey, is the most unpopular fish Pokémon, contrary to Kingdra (rank 182), a dragon seahorse. Luvdisc (rank 595) is inspired from the gourami and Stunfisk (370) by a flounder.



Tentacruel (rank 344) is inspired on jellyfish (not to be confused with a squid, which is a mollusc), whereas the more popular Cloyster (rank 218) in inspired on spiny oysters. Goomy (rank 228) and Pyukumuku (rank 242) are inspired from unsung animal species, respectively a sea slug (as Shellos and Gastrodon) and a sea cucumber.

Invertebrate animals, including here cnidarians, molluscs, and echinoderms, are underrepresented in the Pokémon world, whereas they are extremely diverse in our world, especially in the oceans. Most ranked very low, with only five exceptions above rank 250: Starmie, Cloyster, Goomy, Pyukumuku, Gastrodon. This can be explained because these groups are mostly seen as passive or not very active animals, which is not very attractive for the Pokémon ideology. The majority of these animals have cryptic life styles and/or inhabit unseen environments, as the fish above, so most people do not pay attention to them and do not treat them with the same consideration as vertebrate species (Mather, 2001).

Humanoid and mammal clades

Humanoid and mammalian Pokémon are the most popular after the Dragon and Dinosaur categories. Mammals are a huge success among pokéfans, as expected. Although some (Yungoose, Patrat) are not popular at all (Table 4); which might be related to the fact they are annoying and overrepresented in the games rather than to an aversion to the species that inspired them. There are 195 mammal Pokémon, excluding humanoids, which is equivalent to 24% of all Pokémon. So, these Pokémon were split according to their more specific inspiration (Fig. 5).

Canine Pokémon are the most popular family among mammals; they are the only group with a significantly higher average of votes, whereas all other groups have similar scores. This category includes dogs, of course, which relates to the assimilation of Pokémon as pets. We can however notice that the large success of foxes (which includes Eevee and the eeveelutions) also play a large part in the popularity of canids, because they are represented as cute and joyful, and so easily acceptable as pets. The feline Pokémon, mainly represented by cats, also have a large success. Other pets include the some of the Glires (rodents and lagomorphs), which also have a high popularity score. This latter group includes Pikachu[7] and Jigglypuff, two of the most recognizable mascot Pokémon.

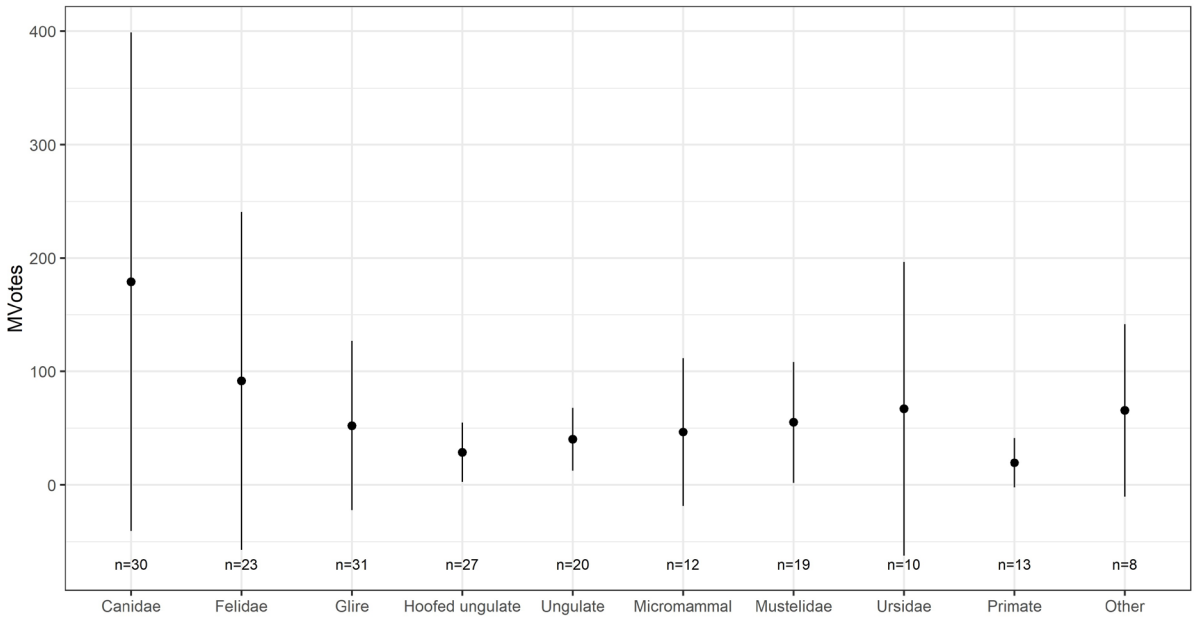
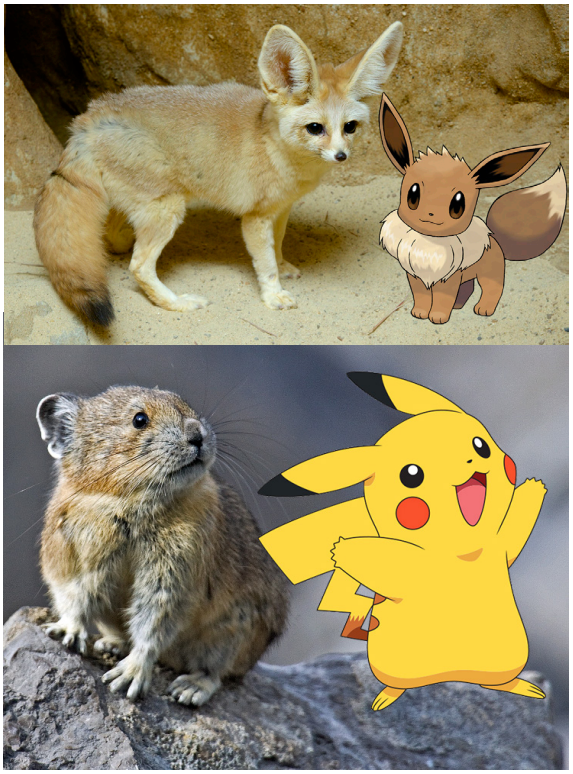


Figure 5. Mean number of votes per large groups of mammals (excluding humanoids and starters). Hoofed (even-toe) ungulates would also include hippos and giraffe, which here instead are included in "Ungulate" instead, to distinguish them from domestic animals. Glires include rodents (mice, rats, squirrels, etc.) and lagomorphs (rabbits, pikas, etc.). Micromammal includes Chiroptera (bats) and Eulipotyphla (moles and hedgehogs). 'Other' includes Xenarthra (sloths, pangolins and ant-eaters) and marsupials.

[7] Just out of curiosity, Pikachu is not very popular considering the incessant marketing surrounding it. It ranks in 44, while Raichu ranks 40 and Pichu ranks 212.



The very popular Eevee (rank 9) and most of its eeveelutions have an appearance similar to a fennec, a desert fox famous for its large ears. The most famous Pokémon of all, Pikachu (rank 44), is often confounded with a mouse, but the pika is related to rabbits and hares (which can explain Pikachu's long ears).

The relationship between humans and their pets became a part of all cultures and domestication of animals was important to our survival. This has made some animals valued members of society and has contributed to the formation of affective links with certain animals. However, and surprisingly, Pokémon representing domestic animals other than pets (that is, horses, pigs, sheep, cows; included here in the Hoofed ungulates), do not have the same amount of success than dogs, cats and rodents/lagomorphs, and even less than most other mammalian groups. The consideration of domestic animals as livestock or transport animals underline the affective separation that humans have between pets and other domestic animals. The affective relation between people and livestock is contradictory and it is a source of main cognitive bias and morality threshold (Holloway, 2001).

The largest Pokémon, Wailord (rank 147), represents the largest living animal of our planet, the blue whale; note that cetaceans are ungulates. Girafarig (rank 307) is a relatively small Pokémon inspired by the cryptic and mysterious okapi and its "cousin", the giraffe, sharing both the horns and the double hoofs, contrary to horses and zebras.

Large carnivorous mammals (Canidae, Felidae, and Ursidae) depend on respondents' assessment of their potential danger and ability to cause damage, while less predatory mammals find wider acceptance (Mustelidae). They are also widely used as flagship animals, like the pandas. Ursidae have a respectable popularity score mainly due to one iconic Pokémon: the ever-hibernating Snorlax. Large carnivorous animals are widely accepted in Pokémon and so in general, despite the human-wildlife conflicts in localised areas.

Mammals are more accepted by humans for their behaviour and resemblance[8] to us and the easiness to empathise. Non-human primates naturally share a lot of features with us and are thus widely accepted. How-

[8] Of course, we are mammals, after all. Weird ones, but still mammals.

ever, the primate Pokémon have mixed popularity compared to others mammals. However, we have to take into account that many Pokémon are represented more in the human side of the spectrum. Humanoid Pokémon collected the largest number of votes after mammals and several are among the most loved Pokémon (Table 2); the exception being the unpopular Gothita and its evolutions (Table 4). The gothic lolita representation might be unpleasant to people, whereas her "rival" Gardevoir[9], which has a mysterious womanly form, is one of the top 10 favourites (Table 2). Several Pokémon are also represented as ghosts, and some are human-like. Humanization of creatures as Pokémon can also underline the ambiguous relation between humans and Pokémon and so with animals.

The legendary Pokémon Suicune (rank 90) represents a snow leopard. Spinda (rank 286) is based on the red panda (a distinct family from the giant panda).

Gothitelle (rank 489) and Gardevoir (rank 8), are the two more woman-like Pokémon

CONCLUSION

With the most favourite Pokémon, we can perceive ecological and social visualisation of animals by humans. Even if further analyses are required to confirm some hypotheses, we can attempt some interpretations of the popularity of Pokémon according to the type of animal they represent.

In this sense, pop culture reflected the same scheme of the construction of a society. The order of popularity of Pokémon reflects that of animals (including imaginary ones) as perceived by humans: dragons, dinosaurs, mammals, and humanoids. Dragons are representative of the mythic and magic in people's imagination, having strong ties with some cultures, religions and art. The high popularity of pet (mammal) Pokémon also draw from the importance of domestication and the affective relation between pets and humans. In modern societies, the acceptance of pets as family members reflects the elevation of status of specific animals, emotionally and physically. This humanisation of animals is reproduced by the success of human-like Pokémon. If Pokémon should be considered as others living beings, their success show that many consider Pokémon not as a tool in the game, but as real companions, creating a strong relationship. *Pokémon* might illustrate the

[9] Be careful if you google this Pokéwaifu!

revaluation of humans as part of the biodiversity and help in the quest to reconsider our relation to other species.

On the contrary, the unpopular Pokémon are considered as "useless", annoying, or simply not very expressive ones. They also reflect the low consideration people have towards these clades as pests or food, and express little to no empathy towards them. Emotion plays an important role in people's choices. If the Pokémon, as the animals, inspire disgust or fear (insects, parasites) they will be less popular and won't be treated with as much consideration as the others.

Pokémon is a contraction of "pocket monster", and their original appellation underlines the idea of them being monsters, as in several other video games. The success of *Pokémon* may be explained by the differentiation in their representation not only as monsters, but as biodiversity at large, and the relationship people can have towards it. *Pokémon* reconsiders our humanity and responsibility to animals, biological modification, and ecological impact, as seen in the story of Mewtwo and the chimeric Type: Null, as well as in the many stories of the impact of humans on the environment.

From a biological and ecological point of view, the Pokémon franchise is quite accurate and try to respect and represent as much as possible the biodiversity around us, despite some creative freedom, such as their nonsense concept of "evolution", and the misnaming of some monsters (which seems to be mostly due to poor translation). The franchise does not try to respect the proportion of macroscopic animals in biodiversity (Mendes et al., 2017; Prado & Almeida, 2017; Kittel, 2018; Salvador & Cavallari, 2019), but rather the representation of biodiversity that modern society has. The knowledge of biodiversity and experience with nature affect the involvement and propensity of people in backing conservation actions for species (Martín-López et al., 2007). People are more likely to protect animals they know and cherish.

Favourite Pokémon are also related to the gaming experience of each one and not all our previous hypotheses can be totally transferred to the real world due to the richness of this gaming culture. Gaming experience is a formidable tool of curiosity: as devoted fans continuously look to improve their knowledge and skills in the game, they end up discovering the complexity and diversity of life around them. Even if the impact of *Pokémon* has been contested at several levels (in most cases by people hostile to Japanese and/or gaming culture), we cannot deny that it creates interest – through generations of gamers – in Biology, which might counteract the decreasing knowledge of younger generations about ecology and systematics. Environmental knowledge and environmental awareness have been repeatedly shown to be important control factors in conservation. *Pokémon* can be for some a first step for respect and conservation of biodiversity and in the end, that's the most important impact of *Pokémon* in our lives.

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About the author

Justine Le Vaillant is an aspiring doctor in evolutionary ecology and Pokémon master in several regions of the *Pokémon* world. With a specialisation in Ornithology, she travelled to many places around the world to observe bird species and try to catch 'em all in photography. Besides her interest in all living creatures, she also likes all mythological and pop culture creatures, with a preference for Ninetales as one of the best Pokémon!

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