Journal of Geek Studies

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Cover art: Examples from the sprite centering pipeline used in the article by Henrique M. Soares (JGS vol. 4(1), pp. 24–38), featuring five Pokémon (The Pokémon Company, 1996–2017): Bulbasaur, Charmander, Squirtle, Pikachu and Lord Helix. See the full article for an extended explanation.

Use of Software Engineering techniques by independent game developers in Brazil

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In this study, I investigated whether Brazilian independent ("indie") game developers use methods and techniques derived from Software Engineering when developing their games. The hypotheses raised in this article are that, even with the vast literature available to guide good development practices, independent developers do not have specialists in their teams in the role of engineer; also, they do not use Software Engineering knowledge when developing their games. All this sums up to several difficulties during game development. Thirty-five indie developers from four Brazilian Internet communities and 13 Facebook groups were interviewed for this study, showing that indie game development in Brazil still lacks professionalism, especially regarding methodological aspects.

DELIMITATION OF THE SUBJECT

A definition of "indie" is given by Lemes (2009: 27 [my translation]): "*a project to be developed without the financial contributions of big companies (…) a game developed by a small team, or individually, by pure passion of the subject or simply to one day make money and start a career in the area of creation and development of digital games*" (see Wikipedia, 2017b, for more information).

There is a bunch of indie games out in the market, some known far and wide, like *Minecraft* and *Angry Birds*, but some famous only within the gaming community, like *To the Moon* (Fig. 1) and *Stardew Valley*. In the Brazilian indie scene, Chroma Squad (Fig. 2) and *Momodora* (Fig. 3) are good examples of the latter case.

Figure 1. *To the Moon*. Screenshot of the game.

The process of game development is (or should be) bustling with engineering techniques, such as project organization, modeling, software metrics, surveying

requirements, and software documentation. According to Pressman (2010: 31), Software Engineering "*encompasses a set of three fundamental elements – methods, tools and procedures – that enables the manager to control the software development process and provides the professional with a basis for building high quality software productively*." However, it is important to point out that Software Engineering was not always present in the development processes among professionals in the field. Pressman (2010: 8) states that at first "*programming was seen as 'an art form'. There were few formal methods and few people used them. The programmer often learned his trade through trial and error. The technical bragging and the challenges of building computer software have created a mystique that few managers cared to penetrate. The software world was virtually undisciplined.*"

Figure 2. *Chroma Squad*. Screenshot of the game.

A digital game is by its nature a computer software and it must go through similar, although not identical, processes during their development. Velasquez (2009: 30 [my translation]) states that, contrary to the usual popular opinion, a "*computer game is not just a toy, but a large and complex software project developed by a vast team of professionals.*" Therefore, similar problems can be detected during the development phases of games and "regular" software, such as: the long production time, the difficulty in measuring progress while the software is being developed, the lack of data collection during development, the late detection of errors, etc. (Pressman, 2010).

Figure 3. *Momodora: Reverie Under the Moonlight*. Screenshot of the game.

Moreover, even with similarities, game development differs in some instances from conventional software development (Morais & Silva, 2009) and still lacks a Software Engineering model dedicated to it (Velasquez, 2009). The importance of engineering methods in game development (and design) are even more obvious when thinking of the final game/software as a product for the market (Lemes, 2009; Lacerda & Selleri, 2012).

In summary, there is agreement in the literature that there is a need for engineering methods in game development, which should be different from conventional methods and

adapted to the specificities of games. By applying such methods, it is possible to maintain a stable project progress control, which will in turn result in a better product. As pointed out by Lacerda & Selleri (2012), the best candidate for this methodology lies in the area called Software Engineering.

The main roles on a team of game developers are: Programmer, Artist, Designer, Producer, Tester, Composer, Sound Designer and Editor (Doolwind, 2017; Wikipedia, 2017c). Among these, the Producer not only oversees the entire team, but is also responsible for the aspects of Software Engineering, including project management. The activities of the Producer are typically undertaken by software engineers (the titles assigned to these positions vary a lot: Engineer, Manager, Game Designer, etc.), evidencing the necessary presence of the engineer in a game development team. Without proper systematization during game development, even the best ideas will fail (Lemes, 2009).

This systematization must start before the production of the game, when the game design is defined and documented (Lemes, 2009): the GDD (Game Design Document) serves as the blueprint from which a game will be built, Sayenko (2015) has a great article describing how and why you have to write a good GDD; one of his tips for coming up with an effective GDD is to put just one person in control of it. From then on, it is the responsibility of the game designer (the engineer) to maintain the GDD.

It is clear that large game companies have specialized software engineers, but independent developers possibly do not. If indie developers lack a person skilled in engineering techniques, they will likely neglect engineering aspects. As stated above, without giving proper importance to such aspects, even the best ideas will not save the project. Therefore, here I analyzed the reality of indie developers in my home country, Brazil. I investigated: (1) if they have specialists in their teams to fill the role of the engineer; (2) if they actually use techniques from Software Engineering for developing their games; and (3) if they have defined and followed a GDD. It was hypothesized that the indie community in Brazil do not comply with the three topics above.

METHODOLOGY

The first step of this study was a survey of the largest Brazilian independent game developer communities, which are mainly based on Internet forums and social media platforms. Only those groups on Facebook with 1,000 or more registered users and online forums with 1,000 or more registered users that are receptive (that is, accept the request to join the group in a period of seven days and do not exclude the search of the feed) were selected (Tables 1 and 2).

The second step was the preparation and application of a questionnaire (see the Appendix) to the groups and forums selected on the first step. The *Google Forms* platform was used for this, as it allows the preparation of online surveys. The questionnaire was semi-open, with objective questions of single and multiple choice, also counting with fields for (optional) further comments and explanations. The questionnaire was composed of 16 questions in total and was presented to the

groups outlined in Tables 1 and 2. The third step consisted in analyzing, interpreting and exposing the collected data in a statistical manner. In this way, the initial hypotheses raised in this study was put to the test.

Table 1. Indie game developers groups on Facebook (last access: 03/Apr/2017).

Group	Members	Website
Construct 2 Br	2,946	https://www.facebook.com/groups/construct2brasil/
Construct 2 Brasil	4,584	https://www.facebook.com/groups/Construct2BR/
Construct 2/3 – Indie Game Brasil	1,380	https://www.facebook.com/groups/construct2indbr/
Desenvolvedores de Games Indie	2,275	https://www.facebook.com/groups/548241321948433/
Desenvolvedores de Jogos Independentes	1,561	https://www.facebook.com/groups/756068824434800/
Games Indie Brasil	1,368	https://www.facebook.com/groups/1135450799818533/
Java Brasil	17,413	https://www.facebook.com/groups/JavaBr/
Python Brasil - Programadores	19,487	https://www.facebook.com/groups/python.brasil/
RPG Maker Brasil	3,646	https://www.facebook.com/groups/418313441606856/
Unity 3D Brasil	16,404	https://www.facebook.com/groups/unity3dbr/
Unity 3D Brasil (1)	7,031	https://www.facebook.com/groups/unity3dbrasil/
Unreal Engine 4 Brasil	5,501	https://www.facebook.com/groups/unrealEngine4Brasil/
Unreal Engine 4 Brasil (Avançado)	1,582	https://www.facebook.com/groups/968146279865089/

Table 2. Online communities of indie game developers (last access: 03/Apr/2017).

Group	Members	Website
Aldeia RPG	16,414	http://www.aldeiarpg.com/
Centro RPG Maker	7,177	http://centrorpg.com/
Game Dev Brasil	4,284	http://www.gamedev.com.br/
Condado Braveheart	1,000	http://www.condadobraveheart.com/

RESULTS & DISCUSSION

The questionnaire remained available for the developer communities for 17 days, during which 35 different questionnaires were answered (without duplicates).

According to the data collected, almost 70% of the independent developers do not use engineering techniques (Fig. 4: Q2). In the circa 30% that do use them, the engineering methods cited are: Design Patterns, MVC (Model-View-Controller), MVVM (Model-View-Viewmodel), MVP (Minimum Viable Product), Scrum, Prototyping, Briefing, and Modeling with Diagrams. (It is not the objective of this article to discuss the different engineering techniques, but, as they are readily available online, I urge the interested reader to look them up.)

In 2013, Fleury et al. (2014) surveyed the methodologies used for software development in Brazilian game companies, noting that circa 25% did not use any methodology. The absence of software development methodologies was deemed worrying, demonstrating the lack of professionalization of this industry in the country. That survey focused on the actual industry (with a large number of respondents), showing that the problem is not something

endemic of independent developers. In any event, it is a much larger problem in the indie community, even when current literature and previous research strongly advocate the importance of engineering methods.

Among those indie developers that do make use of software engineering, most of them (ca. 74%; Fig. 5) opted for not using agile

methodologies. The so-called "Agile Software Development" are a set of principles for development based on the collaborative effort of self-organizing and cross-functional teams (Wikipedia, 2017a). Among those who do use agile methodologies, Scrum is the most used one (ca. 20%; Fig. 5).
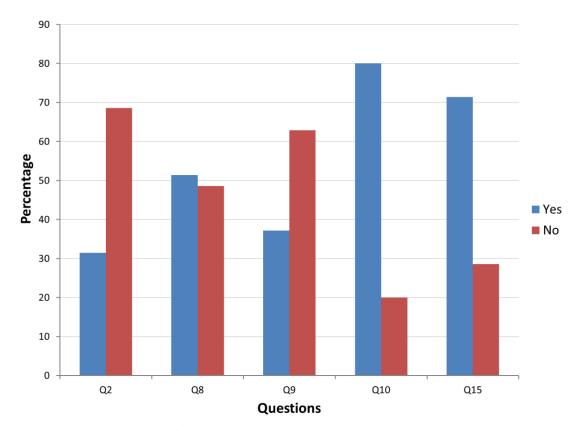
Figure 4. Percentage of answers for Yes/No questions. Question numbers are the same as noted in the Appendix. **Q2:** Do you use engineering methods and techniques in the development process of your game(s)? **Q8:** Do you or your team write a Game Design Document (GDD) at the beginning of your project? **Q9:** Do you and your team follow a system requirements document in game implementation? **Q10:** Do you consider it important to draw up a Game Design Document for your game? **Q15:** Do you consider using software engineering methods important in the process of developing your game(s)?

Another flagrant issue is the lack of a specific professional on the teams who is responsible for the engineering and documentation of the project under development (the Producer mentioned before). By the answers (Fig. 6), having an engineer on

the team is exceedingly rare for independent developers. This position apparently is not deemed important by them, which may explain the rare use of Software Engineering methodologies in their development processes.
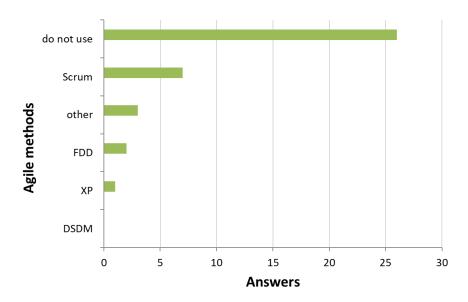
Figure 5. Answers to Q13: Do you use any of these agile methods? Abbreviations: XP = eXtreme Programming; FDD = Feature Driven Development; DSDM = Dynamic System Development Model.
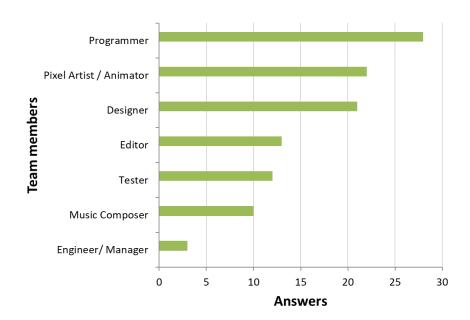
Figure 6. Answers to Q5: Which member(s) make up your development team?

This question can be better understood when we realize that most independent "development teams" actually consist of a single person. About 57% of the interviewed developers work alone, which might explain the usual absence specific software engineering skills, as most programmers are not specialized in this field. It also explains the anecdotal data on the large number of abandoned projects with exhaustively long production times. Things such as this can be estimated with software metrics, provided there is someone (the

engineer, manager, designer, etc.) with the necessary understanding of Software Engineering (Pressman, 2010).

The elaboration of the GDD, as predicted, was also precarious: it is not made by roughly 50% of the interviewees (Fig. 4: Q8). Failing to elaborate a document with the specificities of the product at the beginning of the project can lead to several problems during the game's development process. It is curious, however, that the importance of the GDD is acknowledged by most developers (80%; Fig. 4: Q10).

Similarly, the importance of using engineering techniques is recognized by most developers (ca. 70%; Fig. 4: Q15), even though only a third of those interviewed (Fig. 4: Q2) actually uses them. This data echoes the above-mentioned survey of Fleury et al. (2014) that evidenced the lack of professionalism by Brazilian game developers.

A common difficulty mentioned (by six respondents) is the dissemination and marketing of the product, which is a key factor, naturally, but one that can be addressed at the beginning of the project based on market risk analysis and estimates of the investments required for a future marketing campaign. That is, this is a problem which can be solved or attenuated by engineering skills. Other difficulties raised were the low investments and scarce incentive to independent development (eight respondents), lack of professionalism (three respondents), and lack of time to finish the game (two respondents).

CONCLUSIONS

From the data obtained here, it can be seen that Brazilian independent game developers still lack professionalism, especially regarding adequate methodologies. Curiously, this is recognized as a problem by the developers themselves. The alarming low usage of Software Engineering techniques also highlights the need for instruction and self-guided research on such methodologies.

Of course, that is not to say that all indie developers in Brazil are in this position or that a lack of professionalism permeates the whole industry in the country. However, the large percentage of developers to which these conclusions apply show that this is a real big issue and the importance of using engineering knowledge to manage and produce quality products cannot be over-emphasized. I hope this serves as a call-to-arms for the indie developers to review their position and start studying and applying concepts from Software Engineering. Citing Velasquez (2009: 30) once again: "*[a] computer game is not just a toy, but a large and complex software project developed by a vast team of professionals*" and should therefore be treated as such.

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APPENDIX: QUESTIONNAIRE

1. Email address: _____

2. Do you use engineering methods and techniques in the development process of your game(s)?
- ☐ Yes
- ☐ No

3. If you answered "yes" to Question 2, describe which: _____

4. Who is responsible for the game documentation? Check all that apply.
- ☐ Myself
- ☐ A specialized person (manager, engineer, etc.)
- ☐ Each member documents his/her own work on a single document
- ☐ Each member documents his/her own work on separated documents
- ☐ No one documents or records activities

5. Which member(s) make up your development team? Check all that apply.
- ☐ Programmer
- ☐ Pixel Artist / Animation artist
- ☐ Designer
- ☐ Music Composer
- ☐ Tester
- ☐ Editor
- ☐ Engineer / Manager

6. Describe the platforms, frameworks, game engines you or your team often uses for development: _____

7. Do you work alone or on a team?
- ☐ Alone
- ☐ Team

8. Do you or your team write a Game Design Document (GDD) at the beginning of your project?
- ☐ Yes
- ☐ No

9. Do you and your team follow a system requirements document in game implementation?
- ☐ Yes
- ☐ No

10. Do you consider it important to draw up a Game Design Document for your game?
- ☐ Yes
- ☐ No

11. If you answered "yes" to Question 10, please explain: _____

12. Describe difficulty(-ies) of the independent game development scene: _____

13. Do you use any of these agile methods? Check all that apply.
- ☐ eXtreme Programming (XP)
- ☐ Scrum
- ☐ Feature Driven Development (FDD)
- ☐ Dynamic System Development Model (DSDM)
- ☐ Do not use any
- ☐ Other

14. In case of other agile methods besides those above, please indicate which: _____

15. Do you consider using software engineering methods important in the process of developing your game(s)?
- ☐ Yes
- ☐ No

16. Please explain your answer to Question 15: _____

Medjed: from Ancient Egypt to Japanese Pop Culture

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Not so long ago I have devoted a good deal of time and effort analyzing Egyptian mythology in the *Shin Megami Tensei: Persona* video game series (Salvador, 2015). Thus, it was only natural that I would come back to the topic after the release of *Persona 5* (Atlus, 2017) earlier this year. In my former article, I discussed all the Ancient Egyptian deities and monsters who appeared in *Persona* games. These included the "top brass" of the Egyptian pantheon, like Isis and Horus, alongside several others. *Persona 5*, unfortunately, did not add any new deities to the series roster, but it brought a worthwhile mention to one very peculiar god: Medjed.

WE ARE MEDJED

In *Persona 5*, Medjed is the name of a group of hackers. Better put, it was the pseudonym of one lovely little hacker (Fig. 1) that later became the name of the whole group.

At a certain point in the game, the player receives an ultimatum from Medjed. Their message is very nicely worded, naturally similar to those of real hacker groups, but also (albeit probably unintentionally) curiously reminiscent of the way ancient Egyptian religious texts were written (see, for instance, the spells in the Book of the Dead; Faulkner, 2010). The hackers'

ultimatum also masterfully included the mythology of Medjed, as we will see below. Basically, it says:

> "(…) Do not speak of your false justice. We do not need the spread of such falsehood. We are the true executors of justice. (…) If you reject our offer, the hammer of justice will find you. We are Medjed. We are unseen. We will eliminate evil."
> — Medjed, *Persona 5*

Honestly, I was really surprised to see Medjed referred to in the game, because he is a very minor god. I am talking extraordinarily minor here, maybe barely qualifying to the rank of deity: he is absent from nearly every textbook and encyclopedia of Egyptology. I remembered his name because of his very unusual appearance (as we will see below) and also, pretty much accidentally, knew something about the very scarce mythology behind him — he is mentioned only a couple of times in all inscriptions we currently have from Ancient Egypt.

In any event, I was baffled as to why the game's writers had chosen Medjed. He certainly fits the bill for the whole hacker thing, but so would many other deities and mythological

monsters, from Egypt or elsewhere. And so I decided to investigate the matter of Medjed's popularity in Japan. But before getting into that, let us learn a little bit about this god.

Figure 1. Support's on the way! (Image taken from Megami Tensei Wiki: http://megamitensei.wikia.com/).

THE SMITER

The main source of knowledge on Medjed is the so-called "Greenfield Papyrus" (Fig. 2), where he appears twice. If the name of the papyrus seems a little awkward, that is because it is common for ancient Egyptian artifacts (especially papyri) to be named after the collector who owned it during the heyday of Egyptomania. In this case, this particular papyrus belonged to Mrs. Edith M. Greenfield,

who donated it to the British Museum in 1910. The curator's comments on the online collection of the British Museum summarizes it nicely:

> "The 'Greenfield Papyrus' is one of the longest and most beautifully illustrated manuscripts of the 'Book of the Dead' to have survived. Originally, over thirty-seven metres in length, it is now cut into ninety-six separate sheets mounted between glass. It was made for a woman named Nestanebisheru, the daughter of the high priest of Amun Pinedjem II. As a member of the ruling elite at Thebes, she was provided with funerary equipment of very high quality. Many of the spells included on her papyrus are illustrated with small vignettes, and besides these there are several large illustrations depicting important scenes."
> — British Museum (2017)

The Greenfield Papyrus dates from the historical period known as New Kingdom, possibly from the end of the 21st Dynasty or the beginning of the 22nd, around 950–930 BCE (British Museum, 2017). The vignettes mentioned in the description above appear on top of each sheet in a manner resembling — and I hope Egyptologists will forgive me for this comment — a comic strip (Figs. 2 and 3). (In case you are wondering what a "Book of the Dead" is, I will come back to that in a moment.)

Medjed is featured on the papyrus sheets from Figures 2 and 3. So let us take a closer look at him: he is a shrouded form, like a cartoon ghost (Figs. 4 and 5), but sometimes is described as a mound with eyes and feet (British Museum, 2017). Due to his odd appearance, Medjed is just impossible to miss and/or to ignore, even to the most casual of observers.

Figure 2. Sheet 12 of the Greenfield Papyrus. Picture is a courtesy of the British Museum (©Trustees of the British Museum).

Figure 3. Sheet 76 of the Greenfield Papyrus. Picture is a courtesy of the British Museum (©Trustees of the British Museum).

The text on the papyrus (Fig. 2) names him Medjed (sometimes spelled as "Metchet" in older literature) and says that he "shooteth forth light from his eyes, but is himself invisible" and that he "revolveth in heaven inside a flame produced by his own mouth, whilst his own form is invisible". This translation is according to Budge (1912); although this researcher is a rather controversial figure in Egyptology and his translations are very outdated (for instance, see Goelet et al., 2015), this was the only translation of the Greenfield Papyrus that I could reach. Regardless, it largely agrees with later research on Medjed. The passage above is part of Chapter 17 (or Spell 17) of the Book of the Dead.

So another place to look for Medjed is the same Spell 17 from other copies of the Book of the Dead (they vary, as I will explain later).
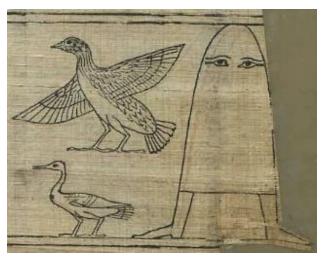
Figure 4. Close-up of Sheet 12 of the Greenfield Papyrus (from Fig. 2) showing Medjed. Just in case, he is the one on the right.
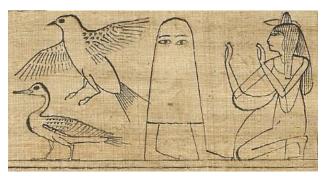

Figure 5. Close-up of Sheet 76 of the Greenfield Papyrus (from Fig. 3) showing Medjed.

As expected, we can find mentions of Medjed in other New Kingdom (and later) papyri, including a group of papyri known as the "Theban Recension of the Book of the Dead". Spell 17 of these papyri are similar to that of the Greenfield Papyrus, but bearing some differences. According to Budge (1898): "I know the being Mātchet [Medjed] who is among them in the House of Osiris, shooting rays of light from [his] eye, but who himself is unseen. He goeth round about heaven robed in the flame of his

mouth, commanding Hāpi [god of the annual flooding of the Nile], but remaining himself unseen." A new translation of this passage is given by Faulkner et al. (2008) and Goelet et al. (2015): "I know the name of that smiter among them who belongs to the House of Osiris, who shoots with his eye, yet is unseen. The sky is encircled with the fiery blast of his mouth and Hapi makes report, yet he is unseen." Medjed is here named "the smiter", or perhaps his name is translated to "smiter". This translation rather deindividualizes Medjed, turning him into just "a smiter": nearly all gods (and mortals) were prone to smite enemies.

To summarize all the information above, Medjed is unseen (hidden or invisible), can fly, can shoot rays of light from his eyes, can breathe fire (like our usual dragon, maybe) and can smite other beings. Besides this, nothing else is known about this god.

In any event, Budge (1904) lists Medjed (as Mātchet) in his chapter on "Miscellaneous Gods", but whether this refers to the same god is uncertain. There, Budge lists the deities who protect Osiris during the 12 hours of the day and the 12 hours of the night; one of them is Medjed. More specifically, Budge (1904) reports that Medjed watches over Osiris during the 1st hour of the day and the 12th hour of the night. This is in line with the passage in Spell 17 where Medjed is said to belong to the House of Osiris, but I could not trace any more recent work reporting this (and Budge's work, as explained above, is mostly shunned by Egyptologists[1]).

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[1] In the sci-fi movie *Stargate* (MGM, 1994), the Egyptologist Daniel Jackson even makes fun of a translation of hieroglyphs he is examining: "Well, the translation of the inner track is wrong. Must've used Budge. I don't know why they keep reprinting his books." (Stargate Wiki, 2017).

THE BOOK OF THE DEAD

Now let us make a brief pause to talk a little about the Book of the Dead. The most important questions to address are: (1) What is it? (2) How it came to be? (3) Is it a single book or is there more than one?

The Book of the Dead is a collection of funerary texts; its use was widespread and lasted for over one and a half millennium (Munro, 2010). The Egyptians called it the "Book of Coming Forth by Day", but "Book of the Dead" was more appealing to the modern audience. The book contained hymns praising the gods and several magical spells (for an example, see Box 1) to protect and guide the deceased through the perilous journey through the Duat, which is the Egyptian underworld (Taylor, 2010). The journey to a nice afterlife was riddled with dangers, fiends and tests, and the deceased needed all the help he/she could get.

The Book of the Dead was not a new invention, however. On the contrary, it has a long history, as it is derived from older writings. During the Old Kingdom, starting in the 5th Dynasty, funerary texts were written on the walls of the burial chambers inside the pharaoh's (and later also the queen's) pyramid (Munro, 2010). These texts, written in hieroglyphic script, are called "Pyramid Texts" — a rather uninventive name, maybe, but efficient nonetheless. They were meant to help the deceased king to reach his rightful place among the gods in the afterlife. Later on, the right to an afterlife ceased to be a royal privilege and first the elite and then everyone was granted access to it (D'Auria et al., 1989).

During the Middle Kingdom, the spells started to be written on the inner side of the coffins (sometimes also on walls and papyri). They are called, as you may have already guessed, "Coffin Texts". Many new spells were added to the repertoire and they were, for the first time, illustrated. Afterwards, new spells were developed and everything started to be written on papyrus; the Book of the Dead thus came into being. The spells could be written either in hieroglyphic script or in hieratic (a cursive form of the hieroglyphs) and were usually richly illustrated.

Box 1. Excerpt from the Book of the Dead

SPELL 83
Spell for being transformed into a phoenix

I have flown up like the primeval ones, I have become Khepri, I have grown as a plant, I have clad myself as a tortoise, I am the essence of every god, I am the seventh of those seven uraei who came into being in the West, Horus who makes brightness with his person, that god who was against Seth, Thoth who was among you in that judgement of Him who presides over Letopolis together with the souls of Heliopolis, the flood which was between them. I have come on the day when I appear in glory with the strides of the gods, for I am Khons who subdued the lords.

As for him who knows this pure spell, it means going out into the day after death and being transformed at will, being in the suite of Wennefer, being content with the food of Osiris, having invocation-offerings, seeing the sun; it means being hale on earth with Re and being vindicated with Osiris, and nothing evil shall have power over him. A matter a million times true.

— Translation by Faulkner (2010: 80).

The oldest known Book of the Dead is from Thebes (around 1700 BCE), during the Second Intermediate Period, and by the New Kingdom, the Book had already become very popular (Munro, 2010).

The most important thing to understand is that there is not a canonical Book of the Dead: when a person commissioned his/her own copy of the Book, they could choose the spells they wanted. Also, there are some differences among books even for the same spells, which can be due to poor copyediting, deliberate omission of parts of the spell or simple evolution through time.

To the modern public, the best-known scene from the Book of the Dead is the Judgement, or the "weighing of the heart" (Fig. 6). This was the most critical step of the journey to the afterlife. The heart of the deceased was weighed against the feather of Maat, the goddess of truth, balance and order. If the person behaved in life in accordance with the principles of Maat, he/she would be granted access to the afterlife. Otherwise, his/her heart would be devoured by Ammit, a goddess whose body was a mix of crocodile, hippopotamus and lioness. This so-called "second death" was permanent and thus much feared by the Egyptians.

So now that this is out of our way, let us return to the original question. Why was Medjed chosen for *Persona 5*? What does he have to do with Japan anyway?

Figure 6. Frame 3 of the Papyrus of Ani (19th Dynasty, ca. 1250 BCE), showing the Judgement scene, also known as "weighing of the heart". Anubis performs the weighing and Thoth records the proceedings. Ammit waits close by in case she has to devour the deceased's heart. Picture is a courtesy of the British Museum (©Trustees of the British Museum).

MEDJED GOES TO JAPAN

Parts of the Greenfield Papyrus were on public display in Japan during the year of 2012 as part of special exhibitions about the Book of the Dead at the Mori Art Museum in Tokyo and the Fukuoka Museum of Art (British Museum,

2017). Visitors to the Tokyo exhibit quickly took notice of Medjed's strangely manga-like appearance and photos of him (on the papyrus) started to circulate on Twitter (Stimson, 2015). As often happens on the Internet, fan art of Medjed started to pop up: there were drawings, comics, toys, cookies, you name it. Soon, any Japanese Medjed fan was able to buy merchandise of the god (Fig. 7).

Figure 7. Left: Plush Medjed (lasers not included). Source: Rakuten Global Market (https://global.rakuten.com). Right: Medjed mug. May this coffee smite your fatigue away! Source: Suzuri (https://suzuri.jp).

Curiously, as the translations of the text from the Greenfield Papyrus said Medjed "shooteth forth light from his eyes", some of the fan art started to depict him — obviously — firing lasers from his eyes. He was also shown flying, which is another of the "superpowers" assigned to him in the Greenfield Papyrus. However, up to my knowledge, no fan art alludes to his fire-breathing ability.

THE SACRED IN POP CULTURE

Medjed was becoming an icon in Japanese pop culture and there was only one thing left to solidify his position as such: video games. In early 2014, the game *Flying Mr. Medjed* was released for mobile phones (Fig. 8) and later on

the same year, Medjed appeared on the popular *Puzzle & Dragons* game (as the character Medjedra; Fig. 9). In this case, the god's power to shoot "forth light from his eyes" is a pair of laser beams, like those earlier fan art pieces.

Figure 8. *Flying Mr. Medjed*. Screenshot of the game.

Figure 9. Medjedra, from *Puzzle & Dragons*. Source: Puzzle & Dragons Wiki (http://pad.wikia.com/).

Medjed was also included in the MMORPG *Aura Kingdom* in a manner very similar to that of *Puzzle & Dragons* (with lasers), but this time under the name Nakama and accompanying a character named Zephyrine (Fig. 10).

Figure 10. Zephyrine and Nakama/Medjed, from *Aura Kingdom*. Source: Aura Kingdom Wiki (http://auraking dom.wikia.com).

Then — and perhaps unavoidably when dealing with Japan — Medjed starred in a dating sim. The game is called *Ejikoi!* (Fig. 11), which translates to something along the lines of "Egy-love". The player takes control of a high school girl looking for romance with one of her classmates, who all happen to be Egyptian deities. As weird as this game may sound, some people must have really liked it, because it is getting a sequel soon.

Figure 11. Characters from *Ejikoi!* Source: Ejikoi Official Twitter (https://twitter.com/ejikoi_official).

Finally, the god got his own anime series in 2016, *Kamigami no Ki* (translated simply as "Chronicles of the Gods"; Fig. 12). The animated series shows Medjed's misadventures alongside his pantheon fellows Ra, Anubis and Bastet.

With such a solid background in Japan's pop culture, it then became clear to me why Medjed was chosen for *Persona 5* in spite of dozens of other more "traditional" candidates. However, instead of flying around and shooting lasers from his eyes, *Persona 5* focuses on the god's role as a smiter and the fact that it remains unseen — both good choices for a shadowy hacker group.

As an enthusiast of everything related to Ancient Egypt, I cannot but smile at this second "chance" Medjed received: he can now shine again in popular folklore, albeit inserted in a very different cultural background (incidentally, one that includes dating sims). Perhaps, given time (and more games) he can even achieve a sort of cult status among fans/followers and be included in a more definite manner in the mixed mythology of RPGs.

Figure 12. The cute gods of *Kamigami no Ki*. Source: MyAnimeList (https://myanimelist.net/).

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ACKNOWLEDGEMENTS

ABOUT THE AUTHOR

Dr. **Rodrigo Salvador** is a zoologist and paleontologist, but he's also fascinated with Ancient Egypt. After all, isn't Archaeology just a tiny portion of Paleontology? One solely focused on a single very odd animal species? In any case, *Persona 5* is now his favorite entry in the series, but he is sick and tired of that dammed cat telling him to go to sleep.

Ants in the *Ant-Man* movie, with biological notes

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Belonging to the family Formicidae (order Hymenoptera), ants are cosmopolitan insects, inhabiting all kinds of terrestrial environments, except the arctic, with nearly 10,000 known species. Ants are also social animals, interacting inside their nests within each caste and each role. These worldwide animals are abundant and dominant in each habitat and niche (Hölldobler & Wilson, 1990), being responsible for a huge nectar consumption (amongst other substances acquired from plants), decomposing organic matter (hence helping with the ecological recycling of nutrients), as well as gathering and transporting seeds (thus helping plant dispersion) (Levey & Byrne, 1993). Artificial systems, such as urban centers, can be colonized and exploited by a variety of ant species. Overall, around 1% of the species could have a huge impact into anthropogenic activities (Zuben et al., 2004).

Ants, among all known insects, are quite prominent within our cultural practices, being frequently named and personified in fables, tales, movies, cartoons and even in more conventional works of art (Doré, 1968; Pérez & Almeralla, 2006; Souza, 2009; Castanheira et al., 2015). The prominent Spanish painter Salvador Dalí, for example, had a notorious passion for ants, which are well characterized in his paintings. Ants are likewise prominent in cartoons, such as *Atom Ant* (Hanna-Barbera Productions, 1965–1968) and *The Ant and The Aardvark* (United Artists, 1969–1971), and films, like *A Bug's Life* (Pixar Animation Studios, 1998) and *Antz* (DreamWorks Pictures, 1998). More importantly for us, ants are featured even in superhero comics and films.

In the present article[1], we list all the ant species shown in the *Ant-Man* movie (Marvel Studios, 2015) and present notes on their biology and distribution. In order to do so, the Blu-ray version of the movie was meticulously watched, observing features such as morphology and behavior, which were then compared to scientific records.

THE ANT-MAN

At least three different characters wore the Ant-Man suit in the Marvel Universe, all of them somehow connected to the famous super hero team, The Avengers. Two of these characters, Hank Pym and Scott Lang, appeared

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[1] This article stems from an original presentation as a poster during the *I Colóquio de Zoologia Cultural* (2016; Rio de Janeiro, RJ, Brazil) and its abstract, published on the event's proceedings (Coelho & Da-Silva, 2016).

in the 2015 movie. The hero's power comes from the so-called Pym particles, a fictional substance that allows him to change and manipulate his size and strengthen his muscles, and a helmet that gives him full control of (and communication with) insects, especially ants.

Figure 1. Cover of *The Avengers* #1 (September, 1964; art by Jack Kirby). Source: Wikimedia Commons.

Doctor Henry "Hank" Pym was the first Ant-Man, the inventor of the Pym particles, and one of the founders of The Avengers team, alongside Iron Man, Thor, the Hulk and Wasp (Fig. 1). Scott Lang was the second man to wear the suit, at first only to save his daughter Cassie Lang from a kidnapper, but afterwards

becoming a hero in his own right. The third Ant-Man was Eric O'Grady, an official from the group called S.H.I.E.L.D. (DeFalco et al., 2009).

THE MOVIE

Ant-Man is an American movie based on the comics, where Scott Lang receives a special suit that allows him to change the size of matter by manipulating the distance between atoms. It is the 12th movie of the Marvel Cinematic Universe (MCU). Starring Paul Rudd as Scott Lang, Evangeline Lilly as Hope van Dyne and Michael Douglas as Hank Pym, the movie was directed by Peyton Reed and a tremendous success, grossing over 500 million dollars.

Figure 2. Promotional poster of the *Ant-Man* movie. Source: Wikimedia Commons.

THE ANTS

Four species are featured in the movie (Fig. 3): the crazy ant (*Paratrechina longicornis*); the bullet ant (*Paraponera clavata*); the carpenter ant (*Camponotus pennsylvanicus*); and the fire ant (*Solenopsis geminata*). These species are presented below in the typical manner of formal biological classification, with comments telling a little more about their biology and discussing how they are depicted in the movie.

Figure 3. Scene from *Ant-Man* showing ant farms with the four different species.

Family Formicidae
Subfamily Formicinae
Tribe Plagiolepidini
Genus *Paratrechina* Motschulsky, 1863
Paratrechina longicornis (Latreille, 1802)
(Figs. 4, 9A)

Paratrechina longicornis are pantropical insects (that is, distributed across the tropics), also present in urban areas and a remarkable agricultural pest (Witte et al., 2007; Ward, 2013). Its common name, crazy ant, is due to its swiftness and agitated behavior. Because of their opportunistic behavior, they are present in degraded areas, sometimes being dominant in this habitat (Wetterer et al., 1999). The movie mentions their well-known swiftness and dexterity, besides the fact that they can conduct electricity. We could not find anything proving the veracity about electrical conductivity in these ants (at least, nothing that would set them apart from all other animals), however, there are records of ants that are so attracted by electricity that they can damage wiring and electronic devices, such as computers and televisions (Slowik et al., 1996; Ball, 2008; Readhead, 2014).

Figure 4. Scenes from the *Ant-Man* movie featuring crazy ants.

Family Formicidae
Subfamily Formicinae
Tribe Camponotini
Genus *Camponotus* Mayr, 1861
Camponotus pennsylvanicus (De Geer, 1773)
(Figs. 5, 9B)

Species of the genus *Camponotus* are cosmopolitan and habitat-dominant organisms (Hölldobler & Wilson, 1990), being the most representative group inside their subfamily. Carpenter ants construct their nests in wood, such as hollow trees, stumps, logs, posts, landscaping timbers, and the lumber used in buildings. This is likely the root of their common name. Nests are usually built in rotten, decayed wood, although some nests may extend into sound heartwood in the center of the tree (ISU Extension and Outreach, 2017).

Camponotus pennylvanicus is widely distributed along the Nearctic region (the region from Greenland to the Mexican highlands), with a few records from the Neotropical region (the remainder of the Americas), setting up the canopy mosaic due to its twig-nesting behavior (Ward, 2013). In the movie, it is mentioned that carpenter ants have good movement and flight capacity.

Figure 5. Scenes from the *Ant-Man* movie featuring carpenter ants.

Family Formicidae
Subfamily Myrmicinae
Tribe Solenopsidini
Genus *Solenopsis* Westwood, 1840
Solenopsis geminata (Fabricius, 1804)
(Figs. 6, 7, 9C)

Ants of the genus *Solenopsis* are commonly named fire ants due to their painful sting. They are also considered a cosmopolitan insect pest in urban areas and the countryside, foraging and nesting on the ground (Wetterer, 2011; Ward, 2013). The species is identified in the movie as *S. mandibularis* Westwood, 1840, which is presently considered a synonym of another species *S. germinata* (Ghosh et al., 2005).

However, it is notoriously difficult to differentiate species within the genus *Solenopsis* (Cuezzo & Fernández, 2015). As such, it is possible that the species shown in the movie could be *S. invicta* Buren, 1972, an exotic species introduced in North-American territory. This species originally inhabits flooding grounds of the Amazon biome, where the colony can aggregate in a boat-shaped way and migrate to other areas through the water, like a rafting boat (Haight, 2006). In the movie, it is said that fire ants are excellent builders, showing the boat-shaped aggregation (Fig. 7).

Figure 6. Scenes from the *Ant-Man* movie featuring fire ants.

Figure 7. Scene from the *Ant-Man* movie where the fire ants build a raft to carry the hero.

Family Formicidae
Subfamily Paraponerinae
Tribe Paraponerini
Genus *Paraponera* F. Smith, 1858
Paraponera clavata (Fabricius, 1775)
(Figs. 8, 9D)

This species is also known as the bullet ant due to its strong and painful sting. They are arboreal (but ground-nesting), medium-sized ants with variable behavior depending on the

habitat they live in (they are spread all around the Neotropical region). There are several studies about their omnivorous feeding behavior, foraging throughout the canopy (Fewell et al., 1996; Ward, 2013). They feed on nectar, however, they prefer animal resources, specially other insects, when available (Fewell et al., 1996). Brazilian indigenous peoples use these ants in rites of passage for teenage boys, who are submitted to the ants' bites (Costa Neto, 2005). In the movie, they mention that the bullet ant sting is one of the most painful there is.

Figure 8. Scenes from the *Ant-Man* movie featuring bullet ants.

FINAL CONSIDERATIONS

The *Ant-Man* movie shows quite a few interesting set of elements, which could be appreciated by the scientific community, entomologists and, especially, myrmecologists (researchers who study ants). Ants have a key role in the plot, being active and helping the leading figure in most situations. For example, Ant-thony, the carpenter-ant named by Scott Lang, is used as a mount throughout the film in order to get the hero to his destination. Such alliance, undoubtedly, allowed for a closer and more humanized relationship with the ants, that were previously addressed to by numbers by the first Ant-Man (and Lang's mentor), Hank Pym.

Another interesting fact, in terms of science, is that all of the ants shown in the movie do behave differently, resulting in different strategies used by Lang depending on the encounter. In the battle taking place at Yellow Jacket's facility, fire-ants conducted Ant-Man through the plumbing, the crazy-ants were responsible for damaging the electronic circuit, the bullet-ants attacked Yellow Jacket's thugs and the carpenter-ants provided air support. In addition, the respective size of the ants was well demonstrated in the movie, which can be observed comparing different species sharing the same scene. Such comparison is also possible using Lang as a reference when he shrinks to the insects' size. In addition, some information regarding the lifestyle of ants are slightly approached in the plot. The capacity that these bugs have to endure and carry extremely heavy objects (in proportion to their own body mass) is mentioned, as well as the "selfless" act of sacrifice in favor of the colony's well-being, typical of social insects. Ant-Man himself benefits from this kind of behavior.

Figure 9. Ant species shown in the *Ant-Man* movie. **A.** *Paratrechina longicornis*. **B.** *Camponotus pennsylvanicus*. **C.** *Solenopsis geminata*. **D.** *Paraponera clavata*. Source: www.AntWeb.org; photos A–C by April Nobile, photo D by Will Ericson.

It seems clear that the whole crew of the movie had a competent advisor about ant biology. However, specific details, such as *Solenopsis mandibularis* being a synonym and the possible mistake regarding *Solenopsis* identification show that, if any entomologist was consulted, probably he/she was not a Formicidae specialist. It was not mentioned during the credits any sort of consulting, although John (2015) revealed that the quantum physicist Dr. Spiros Michalakis (California Institute of Technology) was the scientific consultant. Additionally, some blogs (e.g., Cambridge, 2015; Lobato, 2016) identify the crazy-ant as *Nylanderia fulva* Mayr, 1862; however, we did not find any reason to doubt the identification given in the movie.

All of the aspects presented here can be used in science outreach efforts, including teaching (Da-Silva et al., 2014a; Wolpert-

Gawron, 2015; Da-Silva, 2016). With proper adjustment to a classroom setting, this content could be used as a tool to introduce students (middle school, high school and even college) to science in a much more fun way. For instance, some species mentioned in the plot are urban pests and can impact our quality of life. *Paraponera clavata* does not occur in the Nearctic region, which could be used as a stepping-stone to the subject of introduced fauna. The worldwide genus *Paratrechina* also counts with invasive species, which spread around the world through trade routes and impact society due to hospital and school infestations (Solis et al., 2007).

In terms of science communication and popularization, movies like *Ant-Man* could also strongly contribute to demystify insects as "harmful animals", a non-scientific statement that unfortunately is still common in textbooks and that helps to form the public's negative image of such an important animal group (Da-Silva et al., 2014b). A more humanized treatment towards these (and other) animals in popular culture could be an alternative and suitable way to raise the public's awareness for the conservation of natural resources in our planet.

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Making a vampire

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The modern vampire is often portrayed as a human transformed into a vampire due to a bloodthirsty spirit[1], demons[2], viruses and other pathogens[3], magic or some unknown reason[4]. Neither fiction nor more realistic accounts have shed light on the precise molecular mechanisms of how the transformation happens until the novel trilogy and TV series called *The Strain* (Fig. 1) introduced some ways as to how the transformation could happen. In *The Strain*, parasitic worms carry a virus that causes the vampiric changes to happen through a modification in the expression of genes. This change even creates new organs such as the stinger.

For obvious reasons, no actual experimental studies have been conducted with vampires and so the exact origin and evolution of vampirism remains unknown. A full genome-wide association study or transcriptome analysis would be preferred to recognize the exact genes behind the vampiric traits, but getting enough samples from vampires will most likely be difficult. Thus, the "candidate gene" approach might be the best method for reaching some conclusions or, if there is enough material, a whole genome sequencing and comparison to human genomes.

In this article I will explore some thoughts on how we could make a vampire in the lab and which part of the genome we would need to alter in order to see the necessary changes. Imagine if genetic engineering would be so advanced that when you tweak little bits of the human genome here and there, you could make whatever traits, even vampiric ones, appear (or disappear) any way you like. Unfortunately, reality is seldom as easy, as it has been shown in movies such as *Gattaca* (Columbia Pictures, 1997), Splice (Warner Bros., 2009) and the *X-Men* series (20th Century Fox, 2000–2017), although the genome editing method CRISPR (Cong et al., 2013; Hsu et al., 2014) has lifted genomic modification to a completely new level and has already been used in removing diseases in humans (Ma et al., 2017). Alternatively, what if vampires already existed and we could get our hands on their

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[1] *The Queen of the Damned*, by Anne Rice (1988).

[2] Old folklore; *Buffy the Vampire Slayer* (20th Television, 1997–2003).

[3] *Daybreakers* (Lionsgate, 2010); the *Underworld* film series (Lakeshore Entertainment, 2003–2016); *The Strain* (20th Television, 2014–2017).

[4] *Dracula*, by Bram Stoker (1897); *The Vampire Diaries* (Warner Bros., 2009–2017); *The Twilight Saga* (Summit Entertainment, 2008–2012); *True Blood* (HBO Enterprises, 2008–2014).

genome sequence? Which genes would be affected by the transformation? Intriguingly, there are real life examples of species and conditions that could be thought of as vampiric and we can find potential candidate genes for vampirism from these traits. These "vampire building blocks" could then be used in constructing a lab vampire (at least hypothetically).
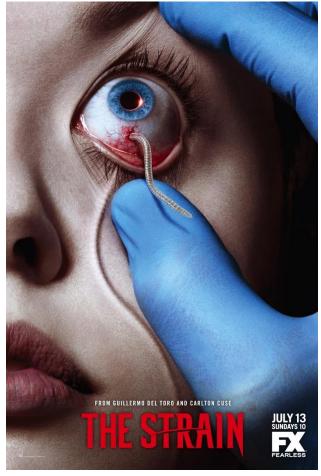

Figure 1. Promotional poster of *The Strain* TV series, directed by Guillermo del Toro and Chuck Hogan. Image retrieved from: IMP Awards (http://www.impawards.com/).

The myth of vampires has been around for thousands of years and the descriptions of vampirism vary between times and cultures.

The vampires we know today date back to the 17th century and they have been covered by every platform in our popular culture. A good summary of the evolution of vampire myths can be found in Harris (2001).

The exact way in which humans transform into vampires depends on the source of the story you are reading and it often remains a mystery. In the extensive study of the science of vampirism, Dr. Pecos and Dr. Lomax (2001–2017) from the late Federal Vampire & Zombie Agency (FVZA) suspected that it is a human vampirism virus (HVV) that causes the transformation. The origin of the virus is suspected to be the vampire bats and their fleas, which sounds very plausible since bats are known to be carriers of many diseases such SARS, ebola and rabies (Biek et al., 2006; Smith & Wang, 2013), and it was also suggested in the movies *Daybreakers* and the *Underworld* series. Furthermore, rabies has been suggested to be the actual origin of the modern vampire myth (Gomez-Alonso, 1998).

In this article, I will present real life examples of vampiric traits and hypothesize possible molecular mechanisms and candidate genes that could be mutated after the transformation. I will concentrate on the following three vampiric traits that are common to many descriptions of vampires:

1. Hematophagy (that is, feeding on blood)
2. Immortality
3. Sunlight avoidance

HEMATOPHAGY

For many people, bloodsucking is the first vampiric trait that comes to mind. Blood is a nutritious fluid tissue, full of proteins and lipids

and it is easy to consume. In nature, blood consumption has evolved in several unrelated species throughout the animal kingdom. Among invertebrates, leeches, mosquitos and fleas are the best known examples, and some fish (lampreys) are also known to feed on blood. There are several bird species that practice hematophagy, such as the oxpeckers, hood mockingbirds and vampire finches. Among mammals, the best known hematophagic species are the vampire bats.

Several changes in the genome are needed in order for animals to survive exclusively on blood. One of the key features is to prevent the victim's blood from coagulating while feeding. In vampire bats the plasminogen activator (PA) genes have gone through gene duplication, domain loss and sequence evolution (Tellgren-Roth et al., 2009). These genes are expressed in the saliva glands of vampire bats and the proteins they produce help to process the blood of birds and mammals. In humans, these genes protect against heart attacks by producing proteins that clear the blood vessels by degrading blood clots. The hairy-legged vampire bat's (*Diphylla ecaudata*) PA genes resemble the PA genes of the closely related non-blood feeding bat species. These bats feed on the blood of birds and it seems that the activation of PA in saliva glands is enough to keep the bird blood flowing. However, in the two bat species that feed on mammal blood, common vampire bats (*Desmodus rotundus*) and white-winged vampire bats (*Diaemus youngi*, which also feed on birds), the PA genes have gone through more extensive modifications in order to better tackle the natural inhibitors of PA proteins in mammal

blood. A transcriptome and proteome study of common vampire bats found additional genes expressed in the salivary glands (Francischetti et al., 2013). Furthermore, by comparing vampire bats and leeches to non-blood feeding species, Phillips & Baker (2015) found additional genes related to blood feeding, such as ectonucleoside triphosphate diphosphohydrolase-1 (*ENTPD1*), which has not before been linked to secretory expression. They also suggest that alternative splicing of genes has been an important mechanism for these species to rapidly evolve to feeding on blood.

In addition to blood coagulation, the vampire bats needed to overcome the bitter taste of blood. Bitterness in nature often means that the substance is poisonous and should be avoided. However, in all of the three vampire bat species there is a greater percentage of non-functioning DNA in the bitter taste receptor genes than in other bat species. These results suggest that these genes have been relaxed from selective constraint in vampire bats, which has led to a reduction of bitter taste function (Hong & Zhao, 2014).

Lastly, the problem with consuming blood is the ratio between amount of nutrition needed and the liquid consumed. A typical vampire bat can consume half of its weight in blood in one feeding. The blood is then rapidly processed and the excess liquids are urinated within two minutes of feeding in order for the bat to take flight. Conceivably, the same effect would not be very convenient for vampires. If the vampire weighed for example 70 kg, it would need to consume 35 kg of blood in one feeding and urinate the excess liquid almost immediately,

because the bladder can only hold about half litre of liquids. Furthermore, humans have about 5 kg of blood on average, so vampires would need to suck dry about seven people per night and urinate between victims, something that has not been discussed or shown in vampire stories, except in *The Strain*, where vampires defecate the blood while drinking. To compensate for the low intake of nutrients, vampires might slow down their metabolism and go to a hibernation mode and thus avoid the need to suck several litres of blood in one go. It would also enable fasting through hard times. In many stories, vampires have managed to survive without blood for days (see below).

IMMORTALITY

Vampires are often regarded as undead; they are dead but behave like living beings, which in turn gives them eternal "life". In this paper, I am not going to discuss whether vampires have a heartbeat or if they breathe (for that we would need actual vampire specimens); I will instead concentrate on how actual immortality could be achieved by giving real life examples.

First, we need to define what immortality is. The concept of biological immortality means that there is no mortality from senescence, which is biological aging. This of course means that the organism is not truly immortal, it can die through injury or disease. Vampires are often presented as highly resilient beings who can survive disease and injuries, but there are things that still kill them, like sunlight, a wooden stake through the heart, fire or beheading.

What is then the ultimate cause of senescence? It is still unclear how the process of senescence happens exactly, since it is a very complex phenomenon. This subject is under heavy research, especially in regard to how we could slow down or even reverse aging (de Keizer, 2017; see movies *Self/less* [Focus Features, 2015] and *Mr. Nobody* [Wild Bunch, 2009] for further thoughts). The research has been concentrating on gene expression changes, chemical and DNA damage, and telomere shortening. Telomeres are repetitive regions at the end of chromosomes. Every time cells divide, the ends of the chromosomes are progressively clipped in the replication process. Because the repetitive sequences in the telomeres are not protein coding, the clipping does not affect cell functions. When the telomeres are gone after a certain number of divisions, the cells stop dividing (Hornsby, 2007). However, cells have ways of replenishing the telomeres with an enzyme called "telomerase reverse transcriptase". The drawback is that the majority of adult somatic (that is, non-reproductive) cells do not express telomerase, but it can be found for example in embryonic stem cells, male sperm cells, epidermal cells and in most cancer cells. In vampires, this enzyme might be active also in the adult somatic cells but this might pose an increased cancer risk. However, vampires might have ways to avoid cancer, as discussed below.

The way senescence happens is not universal; there are species where aging is negligible or cannot even be detected. There are two well-known examples of truly immortal species, the immortal jellyfish (*Turritopsis dohrnii*) and the animals from the *Hydra* genus.

The immortal jellyfish, originally from the Caribbean Sea and now spread around the world, can use the process known as transdifferentiation to rejuvenate itself from its sexually mature free-swimming medusa form to sessile polyp form when the conditions turn harsh for the animal. When conditions are suitable again, the immortal jellyfish again transforms to its medusa form. This cycle can in theory continue forever, making the species immortal in the biological sense. However, this does not save the jellyfish from predators and diseases. The immortal jellyfish also appeared in the TV series *Blacklist* (Sony Pictures Television, 2013–present), where its cells were injected into humans in order to generate immortality. In the real world, science is not that advanced yet and it is also highly unlikely that it would be this easy to achieve immortality.

Hydras have been under more research than the immortal jellyfish. Hydras are simple freshwater animals (also cnidarians, like the immortal jellyfish) whose cells can continually divide and not undergo senescence. One gene, "Forkhead box O" (*FOXO*) has been extensively studied in hydras (and also in other species, like the nematode *Caenorhabditis elegans*, mice and humans) (Boehm et al., 2012; Martins et al., 2016). In hydras, this gene is the main player behind the renewal of the cells. In other species, this gene has been linked to aging and longevity in many studies. In an essay by Schaible & Sussman (2013), the authors suggested that during the evolution of the *FOXO* gene, its function changed from *Hydra*'s life span extending role to many other pathways related to maintenance, which

altered the gene's rejuvenating functions in multicellular eukaryotes such as humans. Thus it might be that in vampires this gene (or actually all the *FOXO* genes – mammals have four of these genes) have retained the original function of *FOXO*s.

In the mammalian world, naked mole rats (*Heterocephalus glaber*) and Brandt's bats (*Myotis brandtii*) are exceptionally long-lived compared to other small sized mammals. Naked mole rats are known for some very peculiar characteristics. They can survive anoxic conditions, they have delayed ageing and live up to 32 years, and the species is highly resistant to cancer, among other things, making them a very interesting species for scientists to study. In studies of the longevity and cancer resistance of this species, scientists found that a gene called *INK4*, which is the most frequently mutated gene in human cancer, produced a new product through alternative splicing. This protein isoform (that is, protein variant), called pALT(INK4a/b), prevented the mutated cells from clustering together and thus made the naked mole rats more resilient to cancer (Tian et al., 2015). In another study by the same group, extremely high-molecular-mass hyaluronic acid was found in naked mole rat fibroblasts (the most common cells in the connective tissue of animals). The molecular weight was over five times larger than that of human or mouse hyaluronic acid. It was speculated that a higher concentration of hyaluronic acid evolved to keep the skin elastic in underground tunnels. In addition to skin elasticity, long hyaluronic acid molecules wrap around cells tightly, preventing tumor cells from replicating (Tian et al., 2013). Whole

genome sequencing revealed additional genes that could be linked to longevity in this species (Kim et al., 2011).

Brandt's bats are known to live for over 40 years, making it the most long-lived mammal of its size. In the whole genome study of the species, Seim et al. (2013) suggested that a combination of different adaptive characteristics such as hibernation, low reproductive rate, cave roosting and an altered growth hormone/insulin-like growth factor 1 axis could extend the Brandt's bat's lifespan. Furthermore, *FOXO1* gene was expressed in high levels in Brandt's bat suggesting a possible role also in the longevity of this species. Hibernation in general has been linked to survival of different species allowing them to withstand extreme conditions (Turbill et al., 2011; Wu & Storey, 2016). The molecular difference between hibernators and non-hibernators seems to be in gene regulation rather than a difference in the DNA sequence itself. Differential expression was detected in the genes that were involved in metabolic pathways, feeding behavior, and circadian rhythms (Faherty et al., 2016). Hibernation or some other kind of dormant state seems to be present in vampires as well, helping them to get through tough times. In the *Vampire Chronicles* by Anne Rice, the vampires go to a hibernation-related state to cope with changing times. In the *Underworld* movies, two of the elders are kept in hibernation while a third reigns over the vampires. The reign goes in cycles, each of elders having their turn over the vampires and slave lycans. This cycle has social reasons, but it also gives rest for the elders from their immortal life.

SUNLIGHT AVOIDANCE

Vampires are creatures of the night and sunlight is often regarded as deadly to them; in many occasions, they burst into flames whenever in contact with sunlight. It is an adverse trait for vampires and most probably emerged through pleiotropism. Pleiotropism is a phenomenon where one gene affects two or more unrelated traits (Paaby & Rockman, 2013). Mutations in genes causing immortality or blood consumption could also cause death by sunlight (antagonistic pleiotropy). Real life examples of bursting into flames due to sunlight are obviously not found, but sun can cause problems to people with certain conditions. Sunlight can cause severe allergic reactions, people can suffer from blood disease called porphyria, or have a rare recessive genetic disorder called "xeroderma pigmentosum".

"Sun allergy" is an umbrella term for a number of conditions where rash and blisters occur on skin that has been exposed to sunlight. Some people have a hereditary type of sun allergy, such as hereditary polymorphous light eruption, others a non-heritable type, such as solar urticaria. In some cases, symptoms only occur when triggered by another factor, such as certain medications or skin exposure to certain plants. The allergic reaction to sunlight occurs in the same way as in any other allergic reaction, although it is still not clear what the triggering component is. Somehow, the immune system recognizes the sun-altered skin as foreign to the body, which in turn activates the immune defences against it. If vampires suffer from sun allergy, could strong antihistamines and a high sun protection factor

sunscreen help them survive under the sunlight, in the same way as people with sun allergies? As death is a very severe reaction to sunlight, it is likely that vampires do not suffer from a sun allergy but from something more serious.

Porphyria, a group of blood diseases, have been suggested as a possible explanation for vampire myths but these ideas have been rejected in later papers (Winkler & Anderson, 1990). However, the mechanism behind porphyria could still shed light on why sunlight would be poisonous for modern vampires. In the cutaneous forms of porphyria where the skin is mostly affected, sunlight can cause pain, blisters or open sores to the patients. The disease is often hereditary due to a mutation in one of the genes that make the heme molecule (a component of hemoglobin, the red pigment in our blood): *ALAD*, *ALAS2*, *CPOX*, *FECH*, *HMBS*, *PPOX*, *UROD*, or *UROS* (Badminton & Elder, 2005). These genes could also be suitable candidates for vampire sunlight avoidance.

There is an even more severe sunlight sensitivity illness, the rare hereditary condition called "xeroderma pigmentosum" (XP). In extreme cases, the patients need to avoid all exposure to sunlight as it can cause severe sunburn with redness and blistering. If not protected from the sun, people with XP have a high risk of developing skin cancer. XP patients' eyes are also very sensitive to sunlight and some of the patients have neurological problems such as seizures and hearing loss. The condition is caused by mutations in the genes that repair DNA damage. This causes a deficiency in DNA repair after ultraviolet damage to cells, which in turn accumulates

abnormalities to the DNA causing the cell to become cancerous or die. In most of XP cases, mutations occur in these four nucleotide excision repair related genes: *POLH*, *XPA*, *XPC* or *ERCC2* (Schubert et al., 2014). In addition to porphyria genes, these are also potential candidates for vampires' adverse reactions to sunlight.

CONCLUSIONS

Obviously, the transformation from human to vampire would affect many genes, some of the changes being bigger than others, which makes the genetic modification of human to vampire even more difficult. From the real life examples, the PA (blood coagulation) and FOXO (immortality) genes seem to be strong candidates. Furthermore, it is also possible to find more suitable genes to test and to investigate interactions between hematophagy, immortality and sun avoidance genes by using network analysis such as Genemania (Warde-Farley et al., 2010). For example, when inserting the human ortholog (roughly put, the equivalent gene) of bat PA gene, the plasminogen activator, tissue type (*PLAT*), the FOXO genes *FOXO1* and *FOXO3*, and the four XP genes, *POLH*, *XPA*, *XPC* and *ERCC2* to Genemania, it is possible to see how the genes are linked and what additional genes might be involved (Fig. 2).

In many of the traits mentioned above, we assumed that mutations in these candidate genes would be the cause of the vampiric traits. However, mutations are not the only possible cause. Epigenetic changes are functional changes in the genome that do not involve modifications in the DNA. Such mechanisms

are, for example, DNA methylation and histone modification. External or environmental effects can cause DNA methylation and change gene expression. In vampires, both mutations and epigenetics could be possible players, causing changes and vampiric traits. Furthermore, if vampirism is caused by a virus or a parasite, we need to take into consideration the possible ways the pathogen could affect the human cells, which is a topic of its own.
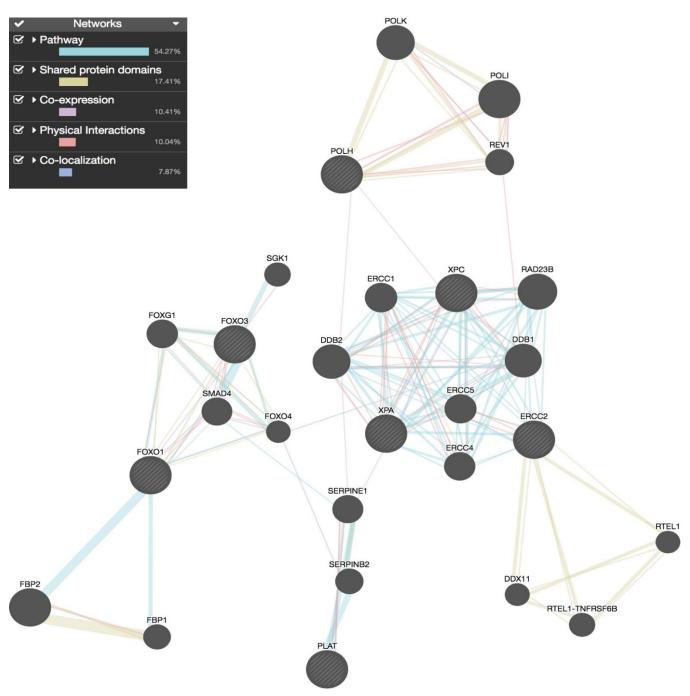

Figure 2. Gene interaction network of the genes PLAT, FOXO1, FOXO3, POLH, XPA, XPC and ERCC2 done with Genemania. Showing 20 related genes with 27 total genes and 207 total links. Input genes are indicated with stripes.

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ACKNOWLEDGEMENTS

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Arthropod diversity in *Pokémon*

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Like most regular children in the 2000's, we were obsessed with *Pokémon* games and anime series. The experience of exploring new environments, discovering new creatures and collecting them, always fascinated us. Maybe this was a sign of what we would become: zoologists. During college, as we got to know ever more about animal biodiversity, we could not help but notice several similarities between Pokémon and real animals. Today, as an arachnologist and an entomologist, and still *Pokémon* fans, our interest in arthropods and admiration for this franchise were the main motivations for this study.

ANIMALS IN THE MEDIA

Animal diversity has always been debated and represented in different types of media. Since the Pleistocene, humans depict animals in their paintings (Aubert et al., 2014), likely reflecting an age-old fascination with nature that still endures. Or, as E. O. Wilson puts it in his "biophilia hypothesis": "humans have an innate desire to catalog, understand, and spend time with other life-forms" (Wilson, 1984). Given this, studies relating Zoology and culture, especially pop culture, are becoming more and more common recently. Just to name some

examples including arthropods, Coelho (2000, 2004) studied insect references in lyrics and cover art of rock music albums, Castanheira et al. (2015) analyzed the representation of arthropods in cinematographic productions, Salvador (2016) studied the biology of giant centipedes in the *Gears of War* game franchise, and Da-Silva & Campos (2017) analyzed the representation of ants in the *Ant-Man* movie. There are even some science outreach works about the *Pokémon* franchise as the analysis of the ichthyological diversity in the Pokémon world (Mendes et al., 2017) and the study of the group of birds popularly called "robins" represented in the game (Tomotani, 2014).

THE ARTHROPODS

Arthropods correspond to the largest part of the known biotic diversity in the world, counting with over 80% of animal diversity (Zhang, 2011a). With lots of morphological variation, the phylum Arthropoda is divided into five subphyla: Trilobitomorpha (the trilobites, now extinct); Chelicerata (arachnids, horseshoe crabs, and others); Crustacea (shrimps, lobsters, crabs, barnacles and woodlice); Hexapoda (insects) and Myriapoda (centipedes and millipedes). With a high

biomass, terrestrial arthropods can be easily seen in a variety of environments, and their presence affects us in several ways.

Although arthropods can inspire fear as venomous creatures or disease vectors, actually most of them are either harmless or important for our own well-being and survival. For instance, many groups of insects are extremely important pollinators and without them, agriculture would collapse. Moreover, terrestrial arthropods have a considerable role as bioindicators for assessing environmental quality (Andersen, 1990; Brown, 1997; Fischer, 2000; Ferrier et al., 2004) and some even have remarkable medicinal uses (Kumar et al., 2015).

POKÉMON, A BRIEF STORY

The word "Pokémon" is a contraction from the Japanese "Pocket Monsters" (ポケモン). The idea consists in fictional creatures – the eponymous Pokémon – that humans can capture and train to do all sorts of chores, the main one of which is fighting each other. Created by Satoshi Tajiri, *Pokémon* was originally a game released in 1996, but its tremendous success soon spawned an anime series, mangas, animated movies, a card game, and countless "goodies" (toys, accessories, clothing, candies, etc.). Developed by Game Freak and published by Nintendo, today *Pokémon* is one of the most successful game franchises in history, with more than 270 million of overall game copies sold around the world (The Pokémon Company, 2017).

The anime series was released in 1997 and was an instant success with kids, remaining so to this day. Many episodes have an environmental tone, showing how humans can

affect the habitats and biodiversity of Pokémon, and emphasizing the importance of collecting for species preservation (Bainbridge, 2013). As a game franchise, *Pokémon* reached mainly teenagers, which remains a loyal customer base to this day. Today, the games are in their seventh generation ("Gen VII") and each generation adds a new territory to be explored and several new creatures to be caught. As of now, there are 802 creatures, but some new ones have already been announced for the second game of Gen VII.

The creator of *Pokémon*, Satoshi Tajiri, loved to collect bugs when he was young, which likely influenced his creation. The Pokémon are mostly inspired by animals and plants and some of them have particular features that can be related to certain real species. In this way, Pokémon biodiversity can be seen as a virtual sample of natural biodiversity.

OBJECTIVES

The main objective of this study is to survey all Pokémon inspired by arthropods, up to Gen VII, and conduct a comparative biological classification of them until the taxonomic level of "Order", if possible[1]. Considering the Pokémon world as a simulation of our own natural world, we also investigate if the different arthropod groups have the same real-world representativeness in Pokémon. This can be done by analyzing the proportion of species of each group.

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[1] Biological classification organizes species into groups. From the largest to the smallest group: Domain, Kingdom, Phylum, Class, Order, Family, Genus, Species. Sometimes subcategories can exist inside one of these, like a "Subphylum" or "Subspecies".
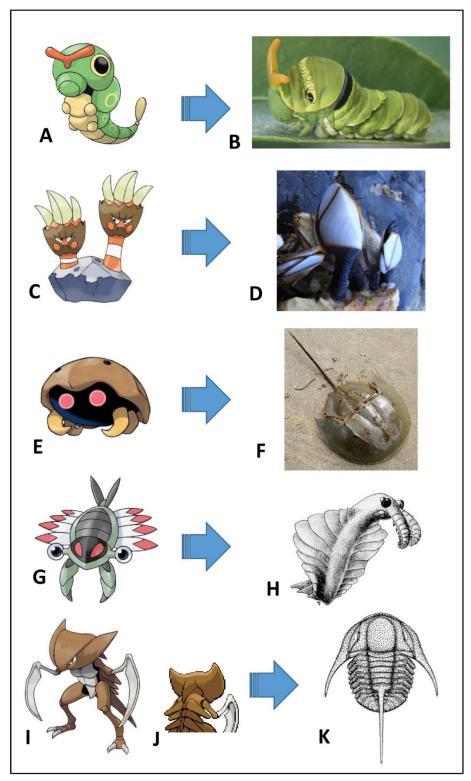
Figure 1. Arthropod-like Pokémon and the real-world species that inspired them. **A.** Caterpie. **B.** *Papilio xuthus* Linnaeus, 1767. **C.** Binacle. **D.** *Lepas anatifera* Linnaeus, 1758. **E.** Kabuto. **F.** *Tachypleus gigas* (Müller, 1785). **G.** Anorith. **H.** *Anomalocaris* sp. **I–J.** Kabutops. **K.** *Dimeropyge speyeri* Chatterton, 1994. Images A, C, E, G, I, J are official artwork from *Pokémon* games (extracted from Bulbapedia); images B, D, F extracted from Wikimedia Commons; image H reproduced from Collins (1996); image K reproduced from Chatterton (1994).

MATERIAL AND METHODS

The sources of information used for this study are: Bulbapedia (https://bulbapedia.bulbagarden.net) and The Official Pokémon Website (https://www.pokemon.com). The Pokémon were classified by Type, Generation, and by their respective taxonomic levels in real-world Biology: Phylum, Subphylum, Class and Order.

The classification into real-world taxonomic levels was made by analyzing morphological and behavioral characters present in the Pokémon species, and comparing them to the relevant animal groups (Fig. 1). Morphological characters were obtained by observing official illustrations and game models. Behavioral characters were obtained from the Pokédex entries of each Pokémon species. Some Pokémon species presented arthropod's

features that were too imprecise to be related to a certain subphyla or order, or their design included features from more than one group of arthropods (for instance, Venonat and Whirlipede). In these cases, the species were marked as "undetermined Subphylum/Order"; regardless, we always classified them to the most accurate level possible.

The biodiversity data used for comparison to the natural world were retrieved from Zhang (2011b).

GENERAL RESULTS

We found a total of 91 Pokémon species inspired by arthropods, representing 11.3% of all Pokémon creatures. Most of them (19) belongs to Gen III, corresponding to 14.1% of the total in this generation (Fig. 2, Table 1).
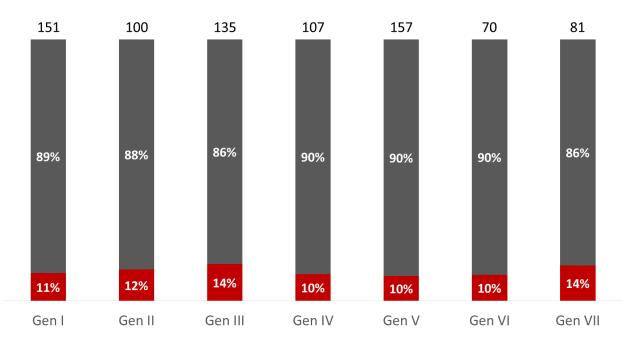

Figure 2. Proportion of Pokémon inspired by arthropods (red) compared to the other monsters (dark grey) from each generation of the game. Total number of Pokémon per generation is shown above each bar.

Table 1. Pokémon inspired by arthropods, with their Pokédex number, Generation, Type(s) and their pertinent biological classification. Horizontal lines separate the game Generations. Symbols: *Wormadam secondary Type might be Steel, Grass or Ground; †fossil group; "???" indicates an undetermined taxonomic position.

Number	Pokémon	Gen	Types		Subphyla	Class	Order
					Taxonomic Classification		
#010	Caterpie	I	Insect	-	Hexapoda	Insecta	Lepidoptera
#011	Metapod	I	Insect	-	Hexapoda	Insecta	Lepidoptera
#012	Butterfree	I	Insect	Flying	Hexapoda	Insecta	Lepidoptera
#013	Weedle	I	Insect	Poison	Hexapoda	Insecta	Hymenoptera
#014	Kakuna	I	Insect	Poison	Hexapoda	Insecta	Hymenoptera
#015	Beedrill	I	Insect	Poison	Hexapoda	Insecta	Hymenoptera
#046	Paras	I	Insect	Grass	Hexapoda	Insecta	Hemiptera
#047	Parasect	I	Insect	Grass	Hexapoda	Insecta	Hemiptera
#048	Venonat	I	Insect	Poison	Hexapoda	Insecta	???
#049	Venomoth	I	Insect	Poison	Hexapoda	Insecta	Lepidoptera
#098	Krabby	I	Water	-	Crustacea	Malacostraca	Decapoda
#099	Kingler	I	Water	-	Crustacea	Malacostraca	Decapoda
#123	Scyther	I	Insect	Flying	Hexapoda	Insecta	Mantodea
#127	Pinsir	I	Insect	-	Hexapoda	Insecta	Coleoptera
#140	Kabuto	I	Rock	Water	Chelicerata	Merostomata	Xiphosura
#141	Kabutops	I	Rock	Water	†Trilobitomorpha	†Trilobita	†Proetida
#165	Ledyba	II	Insect	Flying	Hexapoda	Insecta	Coleoptera
#166	Ledian	II	Insect	Flying	Hexapoda	Insecta	Coleoptera
#167	Spinarak	II	Insect	Poison	Chelicerata	Arachnida	Araneae
#168	Ariados	II	Insect	Poison	Chelicerata	Arachnida	Araneae
#193	Yanma	II	Insect	Flying	Hexapoda	Insecta	Odonata
#204	Pineco	II	Insect	-	Hexapoda	Insecta	Lepidoptera
#206	Dunsparce	II	Normal	-	Hexapoda	Insecta	Hymenoptera
#207	Gligar	II	Ground	Flying	Chelicerata	Arachnida	Scorpiones
#212	Scizor	II	Insect	Steel	Hexapoda	Insecta	???
#214	Heracross	II	Insect	Fighting	Hexapoda	Insecta	Coleoptera
#247	Pupitar	II	Rock	Ground	Hexapoda	Insecta	???
#251	Celebi	II	Psychic	Grass	Hexapoda	Insecta	???
#265	Wurmple	III	Insect	-	Hexapoda	Insecta	Lepidoptera
#266	Silcoon	III	Insect	-	Hexapoda	Insecta	Lepidoptera
#267	Beautifly	III	Insect	Flying	Hexapoda	Insecta	Lepidoptera
#268	Cascoon	III	Insect	-	Hexapoda	Insecta	Lepidoptera
#269	Dustox	III	Insect	Poison	Hexapoda	Insecta	Lepidoptera
#283	Surskit	III	Insect	Water	Hexapoda	Insecta	Hemiptera
#284	Masquerain	III	Insect	Flying	Hexapoda	Insecta	Lepidoptera
#290	Nincada	III	Insect	Ground	Hexapoda	Insecta	Hemiptera
#291	Ninjask	III	Insect	Flying	Hexapoda	Insecta	Hemiptera
#292	Shedinja	III	Insect	Ghost	Hexapoda	Insecta	Hemiptera
#313	Volbeat	III	Insect	-	Hexapoda	Insecta	Coleoptera
#314	Illumise	III	Insect	-	Hexapoda	Insecta	Coleoptera
#328	Trapinch	III	Ground	-	Hexapoda	Insecta	Neuroptera
#329	Vibrava	III	Ground	Dragon	Hexapoda	Insecta	Neuroptera
#330	Flygon	III	Ground	Dragon	Hexapoda	Insecta	Neuroptera
#341	Corphish	III	Water	-	Crustacea	Malacostraca	Decapoda
#342	Crawdaunt	III	Water	Dark	Crustacea	Malacostraca	Decapoda
#347	Anorith	III	Rock	Insect	???	†Dinocaridida	†Radiodonta
#348	Armaldo	III	Rock	Insect	???	†Dinocaridida	†Radiodonta

Table 1. (cont.)

| Number	Pokémon	Gen	Types		Subphyla	Class	Order
					Taxonomic Classification		
#401	Kricketot	IV	Insect	-	Hexapoda	Insecta	Coleoptera
#402	Kricketune	IV	Insect	-	Hexapoda	Insecta	Coleoptera
#412	Burmy	IV	Insect	-	Hexapoda	Insecta	Lepidoptera
#413	Wormadam	IV	Insect	Variable*	Hexapoda	Insecta	Lepidoptera
#414	Mothim	IV	Insect	Flying	Hexapoda	Insecta	Lepidoptera
#415	Combee	IV	Insect	Flying	Hexapoda	Insecta	Hymenoptera
#416	Vespiquen	IV	Insect	Flying	Hexapoda	Insecta	Hymenoptera
#451	Skorupi	IV	Poison	Insect	Chelicerata	Arachnida	Scorpiones
#452	Drapion	IV	Poison	Dark	Chelicerata	Arachnida	Scorpiones
#469	Yanmega	IV	Insect	Flying	Hexapoda	Insecta	Odonata
#472	Gliscor	IV	Ground	Flying	Chelicerata	Arachnida	Scorpiones
#540	Sewaddle	V	Insect	Grass	Hexapoda	Insecta	Lepidoptera
#541	Swadloon	V	Insect	Grass	Hexapoda	Insecta	Lepidoptera
#542	Leavanny	V	Insect	Grass	Hexapoda	Insecta	Phasmatodea
#543	Venipede	V	Insect	Poison	Myriapoda	Chilopoda	???
#544	Whirlipede	V	Insect	Poison	Myriapoda	???	???
#545	Scolipede	V	Insect	Poison	Myriapoda	Chilopoda	Scolopendromorpha
#557	Dwebble	V	Insect	Rock	Crustacea	Malacostraca	Decapoda
#558	Crustle	V	Insect	Rock	Crustacea	Malacostraca	Decapoda
#588	Karrablast	V	Insect	-	Hexapoda	Insecta	Coleoptera
#589	Escavalier	V	Insect	Steel	Hexapoda	Insecta	Coleoptera
#595	Joltik	V	Insect	Electric	Chelicerata	Arachnida	Araneae
#596	Galvantula	V	Insect	Electric	Chelicerata	Arachnida	Araneae
#632	Durant	V	Insect	Steel	Hexapoda	Insecta	Hymenoptera
#636	Larvesta	V	Insect	Fire	Hexapoda	Insecta	Lepidoptera
#637	Volcarona	V	Insect	Fire	Hexapoda	Insecta	Lepidoptera
#664	Scatterbug	VI	Insect	-	Hexapoda	Insecta	Lepidoptera
#665	Spewpa	VI	Insect	-	Hexapoda	Insecta	Lepidoptera
#666	Vivillon	VI	Insect	Flying	Hexapoda	Insecta	Lepidoptera
#688	Binacle	VI	Rock	Water	Crustacea	Cirripedia	Pedunculata
#689	Barbaracle	VI	Rock	Water	Crustacea	Cirripedia	Pedunculata
#692	Clauncher	VI	Water	-	Crustacea	Malacostraca	Decapoda
#693	Clawitzer	VI	Water	-	Crustacea	Malacostraca	Decapoda
#736	Grubbin	VII	Bug	-	Hexapoda	Insecta	Coleoptera
#737	Charjabug	VII	Bug	Electric	Hexapoda	Insecta	Coleoptera
#738	Vikavolt	VII	Bug	Electric	Hexapoda	Insecta	Coleoptera
#739	Crabrawler	VII	Fighting	-	Crustacea	Malacostraca	Decapoda
#740	Crabominable	VII	Fighting	Ice	Crustacea	Malacostraca	Decapoda
#742	Cutiefly	VII	Bug	Fairy	Hexapoda	Insecta	Diptera
#743	Ribombee	VII	Bug	Fairy	Hexapoda	Insecta	Diptera
#751	Dewpider	VII	Water	Bug	Chelicerata	Arachnida	Araneae
#752	Araquanid	VII	Water	Bug	Chelicerata	Arachnida	Araneae
#794	Buzzwole	VII	Bug	Fighting	Hexapoda	Insecta	Diptera
#795	Pheromosa	VII	Bug	Fighting	Hexapoda	Insecta	Blattodea
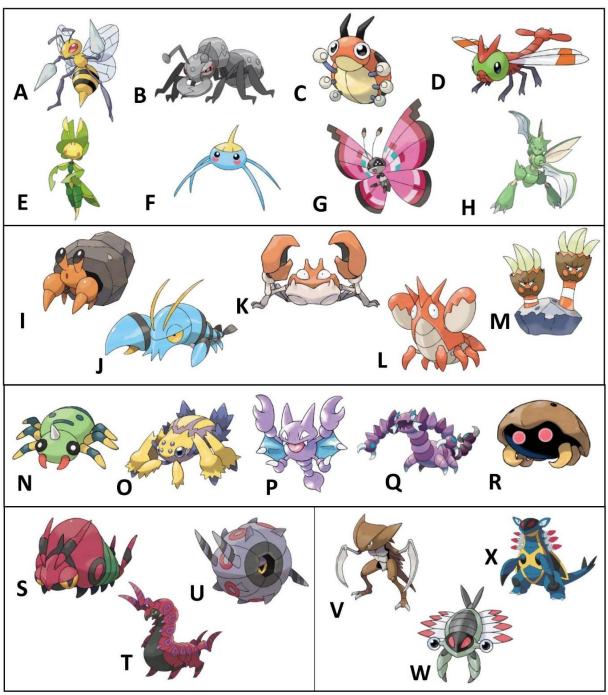
Figure 3. Examples of Pokémon inspired by arthropods, separated according to subphyla. **A–H.** Hexapoda: **A–B.** Hymenoptera (Beedrill, Durant); **C.** Coleoptera (Ledyba); **D.** Odonata (Yanma); **E.** Phasmatodea (Leavanny); **F.** Hemiptera (Surskit); **G.** Lepidoptera (Vivillon); **H.** Mantodea (Scyther). **I–M.** Crustacea: **I–L.** Decapoda (Dweeble, Clauncher, Krabby, Corphish); **M.** Pedunculata (Binacle). **N–R.** Chelicerata: **N–O.** Araneae (Spinarak, Galvantula); **P–Q.** Scorpiones (Gligar, Drapion); **R.** Xiphosura (Kabuto). **S–U.** Myriapoda: **S–T.** Chilopoda (Venipede, Scolipede); **U.** undetermined order (Whirlipede). **V–X.** extinct taxa: **V.** Proetida (Kabutops); **W–X.** Radiodonta (Anorith, Armaldo). The illustrations are official artwork from the games; images were extracted from Bulbapedia.

TAXONOMIC RESULTS

Most of the Pokémon species could be classified into the four main living subphyla of Arthropoda: Hexapoda (Figs. 3A–H), Crustacea (Figs. 3I–M), Chelicerata (Figs. 3N–R) and Myriapoda (Figs. 3S–U). The three exceptions were: Kabutops, Anorith and Armaldo (Figs. 3V–X). The former was allocated to the entirely fossil subphylum Trilobitomorpha. The latter two were allocated into another fossil group, with an uncertain position inside Arthropoda (or even an external group, according to some researchers). They belong to the Class Dinocaridida, Order Radiodonta (this ranking is still highly debated, though) and are popularly known as "terror shrimps".

The Arthropoda subphylum that inspired most of the Pokémon species was Hexapoda, with 62 pokémon, followed by Crustacea (12), Chelicerata (11) and Myriapoda (3) (Figs. 4–5).

The taxonomical order that inspired most of the arthropod Pokémon was Lepidoptera, represented by 21 species. This can be explained by the huge visual appeal and beauty of butterflies and moths. This explanation can be also applied to the large number of Pokémon inspired by the order Coleoptera (13 species), the beetles, animals with an astounding variation of colors and shape. The third order in diversity is Decapoda (10 species), represented by crabs and shrimps.
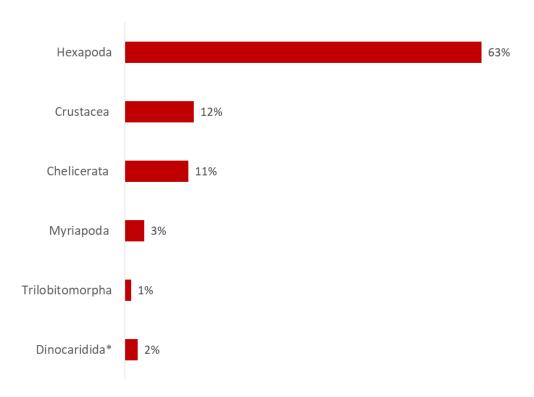

Figure 4. Representativeness (in proportion) of Pokémon species inspired by each Arthropoda subphylum. *Dinocaridida is usually considered a class, with uncertain position in Arthropoda.
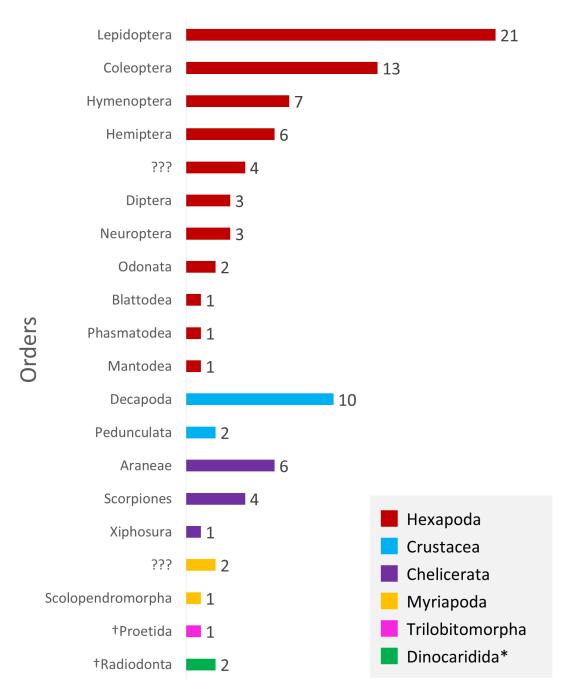
Figure 5. Number of Pokémon species inspired by each order inside each subphylum of Arthropoda. *Dinocaridida is usually considered a class, with uncertain position in Arthropoda. "???" indicates an undetermined order.

POKÉMON DIVERSITY vs NATURAL DIVERSITY

The large number of Pokémon inspired by Hexapoda is congruent with the high diversity of this group in the natural world (Table 2). The fact that there was more Pokémon inspired in Crustacea (Table 3) than in Chelicerata (Table 4) is at odds with natural diversity, but can be related to the very frequent contact that Japanese people have with aquatic animals, which are one of the country's main food

sources (Ashkenazi & Jacob, 2003). The few specimens of Myriapoda in the game are proportionally congruent with their diversity in nature (Table 5).

The comparison between natural and Pokémon diversity shows that the Pokémon world presents higher representativeness of arthropod-like creatures that are more familiar to people or that have a greater visual appeal. The latter is the case of Lepidoptera (Fig. 5), whose diversity in the Pokémon world is much higher than the second place (Coleoptera). However, beetles are the most diverse insect (and overall animal) group in the real world, with approximately 387,000 species, while lepidopterans count "just" with around 157,000 species (Zhang, 2011b). Proportionally, butterflies and moths represent 33.9% of Hexapoda in *Pokémon*, while in nature this percentage is much closer to that of Coleoptera within Hexapoda (37.6%) rather than the proportion of Lepidoptera (15.3%) (Table 2).

Table 2. Comparison between the diversity of Pokémon species inspired by **Hexapoda** orders and their respective representativeness in the natural world (Zhang, 2011b).

Pokémon		Nature	
Orders	Nr. of species (%)	Orders	Nr. of species (%)
Lepidoptera	21 (33.9%)	Coleoptera	387,100 (37.6%)
Coleoptera	13 (21.0%)	Diptera	159,294 (15.5%)
Hymenoptera	7 (11.3%)	Lepidoptera	157,424 (15.3%)
Hemiptera	6 (9.7%)	Hymenoptera	116,861 (11.3%)
Neuroptera	3 (4.8%)	Hemiptera	103,590 (10.0%)
Diptera	3 (4.8%)	Blattodea	7,314 (0.7%)
Odonata	2 (3.2%)	Odonata	5,899 (0.6%)
Blattodea	1 (1.6%)	Neuroptera	5,868 (0.6%)
Phasmatodea	1 (1.6%)	Phasmatodea	3,029 (0.3%)
Mantodea	1 (1.6%)	Mantodea	2,400 (0.2%)
undetermined	4 (6.5%)	others	80,962 (7.9%)
Total	62 (100%)	**Total**	1,029,741 (100%)

Table 3. Comparison between the diversity of Pokémon species inspired by **Crustacea** orders and their respective representativeness in the natural world (Zhang, 2011b).

Pokémon		Nature	
Orders	Nr. of species (%)	Orders	Nr. of species (%)
Decapoda	10 (83.3%)	Decapoda	14,756 (22.1%)
Pedunculata	2 (16.7%)	Pedunculata	457 (0.7%)
undetermined	0 (0.0%)	others	51,701 (77.3%)
Total	12 (100%)	**Total**	66,914 (100%)

Table 4. Comparison between the diversity of Pokémon species inspired by **Chelicerata** orders and their respective representativeness in the natural world (Zhang, 2011b).

Pokémon		Nature	
Orders	Nr. of species (%)	Orders	Nr. of species (%)
Araneae	6 (54.5%)	Araneae	43,579 (38.8%)
Scorpiones	4 (36.4%)	Scorpiones	2,068 (1.8%)
Xiphosura	1 (9.1%)	Xiphosura	98 (0.1%)
undetermined	0 (0.0%)	others	66,456 (59.2%)
Total	11 (100%)	**Total**	112,201 (100%)

Table 5. Comparison between the diversity of Pokémon species inspired by **Myriapoda** orders and their respective representativeness in the natural world (Zhang, 2011b).

Pokémon		Nature	
Orders	Nr. of species (%)	Orders	Nr. of species (%)
Scolopendromorpha	1 (33.3%)	Scolopendromorpha	678 (5.7%)
undetermined	2 (66.7%)	others	11,207 (94.3%)
Total	3 (100%)	**Total**	11,885 (100%)

CONCLUSION

The large number of Pokémon inspired by arthropods indicates that this group, even though not as charismatic as mammalians or birds, still plays an important role in pop culture. The visual appeal and the everyday contact seems to be important aspects that ensure a higher diversity to certain arthropod-like groups in *Pokémon*. Nevertheless, the Pokémon world still seems to be a good virtual sample of the natural world and this kind of representation can be an interesting source for educational purposes, helping young people to know other type of animals that they do not usually have much contact with, including extinct species.

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Ruby Rei: How to make an adventure video game to learn languages

Truan Flynn

Wibbu Studios. London, UK.

Learning is an active process. Goals are set. Achievements are unlocked. Progress is made. So it isn't a huge leap to marry the worlds of education and gaming as one successful and fulfilling experience. Wibbu's play-based learning system pulls down the learning barriers that are outlined in Stephen Krashen's Affective Filter hypothesis. Krashen posited that the more a learner is stressed, embarrassed, or bored, the more demotivated they will become. How do you overcome the affective filter? Make learning an adventure!

We've created a system with our language-learning video game, *Ruby Rei*, where players are totally engaged in a story and characters. We distract our students into absorbing information that benefits their progress.

Ruby explores all kinds of amazing places. (Screenshot of the game.)

Players join Ruby as she crash-lands on a forgotten planet at the edge of the universe. Embarking on an education epic to save her friends and return home, Ruby works on her communication skills as she meets meek monsters, awkward aliens, and a less-than-helpful lizard sidekick.

Ruby Rei's learning system is built around play-based, immersive language exploration. Students learn with Ruby! She visits, she catalogues, and she communicates. Through the technique of incidental learning, players absorb lessons through story points, and acquire language through character interaction.

Before our games can teach a language, a fictional world has to be created that can support the narrative. Any sci-fi or fantasy writer will tell you that world building is an immensely fun and satisfying process. The details of character, place, and motivation are what make a story come alive. And the key to building a story for players to live in for extended periods, is in creating situations that grab hold of the imagination. With *Ruby Rei* we make story foundations that allow players to dream and create their own stories.

Once a script has been written, each scene, sentence and word is then analysed by our team of linguists and teachers. Grammar points are highlighted, teachable moments are extracted, potentially confusing situations are refined and the script gets better and better. This can be a lengthy editing process, but it results in a game that maintains the integrity of the characters but is confident in its ability to teach.

There is no better place to learn new stuff than a *bosque sagrado*. (Screenshot of the game.)

Our game designers then create interactive puzzles that draw the player into a cycle of challenge and reward. We approach each 'lesson' with unconventional goals. Instead of learning a number of nouns and verbs, the primary aim may be to find a spaceship. Instead of learning a new grammatical structure, the desire may be to rescue a friend in danger. Creating these primary desires in a player that distract from the subconscious learning is what makes a successful educational video game work.

When *Ruby Rei* was independently tested in schools in July 2017, it was found to improve pupil motivation and engagement four times more than the comparative resources. Over the course of a week, children elected to play the game four times longer, immersed in the story, and having fun as they learnt!

So we can recommend from experience the power of play-based education for building confidence, reducing embarrassment, and creating a safe environment for children to lose themselves in learning. Suddenly, a thing that might have elicited feelings of dread is now a pupil's favourite lesson!

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ABOUT THE AUTHOR

Truan Flynn is a graduate of the University of Brighton, UK. He is the educational writer for Wibbu Studios and believes that the best learning is powered by imagination. His life and work is powered by the motto, "what would Batman do?"

The plants of J.R.R. Tolkien's legendarium

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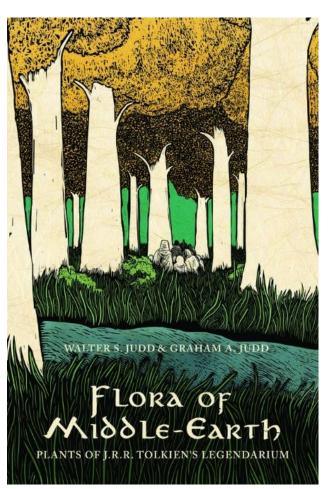[2]*Florida Museum of Natural History. Gainesville, FL, U.S.A.*
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Many readers of *The Hobbit* or *The Lord of the Rings* believe that the events of these books occur in an imaginary world and thus have no connection with the world around us. However, John Ronald Reuel Tolkien sought to correct this misconception, stating that Middle-earth "is just the use of Middle English *middle-erde* (or *erthe*), altered from Old English *Middangeard*: the name for the inhabited lands of Men 'between the seas.'" He went on to say that "imaginatively this 'history' is supposed to take place in a period of the actual Old World of this planet" (Tolkien, 1981, Letter No. 165). His writings should not be considered escapist, but instead are meant to reconnect us to important elements of our internal and cultural landscape. They should also influence how we interact with other individuals and with the world in which we live — including the landscapes of our natural environment — and especially plants! The importance of plants in the Tolkien's Middle-earth is thus considered in detail in our book, *Flora of Middle-Earth: Plants of J.R.R. Tolkien's Legendarium*, recently published by Oxford University Press (Judd & Judd, 2017), which we introduce here, along with an introduction to the importance of plants in connection with Tolkien's imaginative world.

Flora of Middle-Earth (book cover, showing forest of Lothlórien).

Our book focuses on one of the major components of our environment — the Green Plants — organisms to which many in our modern, highly technological world have become blind (Wandersee & Schussler, 2001; Allen, 2003). Indeed, some have argued that we are now disconnected from the entire natural world (Yoon, 2009). Plants are ecologically diverse and range dramatically in size — from microscopic, aquatic, green algae to the tallest flowering trees or conifers. They are critically important in maintaining a healthy biosphere — and in fact, without plants, animal (and, of course, human) life would be impossible. They provide our food, construction materials for our homes, add beauty to our surroundings, and even provide the air we breathe. In Tolkien's legendarium, plants are the primary concern of Yavanna Kementári, the Giver of Fruits and wife of Aulë, who has lordship over all the substances of which the Earth is made. As related in *The Silmarillion*, she is the "lover of all things that grow in the earth, and all their countless forms she holds in her mind, from the trees like towers in forests … to the moss upon stones or the small and secret things in the mould" (*Valaquenta*: p. 27). Understandably, she is held in great reverence by the elves, as are the natural environments she oversees. We believe Tolkien's reference was comparable.

Tolkien's descriptions of Middle-earth are richly detailed, including succinct verbal sketches of many of its plants, and thus create a realistic stage for his dramas. His detailed treatment of plants plays a major role in the creation of this stage — providing the distinctive landscapes and natural locales of Middle-earth — from the tundra and ice-fields of the north, to the extensive prairies of Rohan, and the coniferous forests of Dorthonion, as well as the broad-leaved forests of Doriath or Fangorn and wetlands such as the Gladden Fields. The dominant species within each plant community are always mentioned, especially the trees, which Tolkien, like Yavanna, held most dear (see *The Silmarillion*: chapter 2). Thus, it is critical for our appreciation and understanding of Middle-earth to envision these scenes accurately. These plants, however, do more than merely provide descriptive detail, enhancing the veracity of the tales of Middle-earth. The plants within Tolkien's legendarium are actually part of the story, and in ways that are more deeply significant than merely evident in the actions of Ents — anthropomorphized trees — that "speak on behalf of all things that have roots, and punish those that wrong them" (*The Silmarillion*: p. 45). Their significance can be seen in the numerous connections between plants and important individuals in the myths and history of Middle-earth. For example, in the First Age (and earlier), how are we to understand the Two Trees of Valinor, fashioned by Yavanna, and why is it important that Thingol, the elven ruler of Doriath, was called the king of beech, oak, and elm? Why was his daughter, Lúthien, when first observed by Beren, dancing among the hemlock-umbels under the beeches of Neldoreth? And what is the link between her feet and the leaves of lindens? Why did hawthorns obscure the entrance to the Hidden Kingdom of Gondolin? During the Second Age, why did the elves give Aldarion, soon to become the sixth king of Númenor, a White Tree — Nimloth — and what is the connection between this tree and the White Trees of Gondor? Why

did the elves bring to Númenor several different fragrant trees from Eressëa — and what did these trees look like? In the Third Age, how was pipe-weed integral to the culture of the Shire, and why was athelas (kingsfoil) useful in the hands of the king of Gondor? How did these two herbs get to Middle-earth? What is the connection of willows and the Withywindle valley (in the Old Forest), and should willows, therefore, be viewed negatively? Why does Quickbeam love rowan-trees, and why were mallorn-trees important to Galadriel and the elves of Lothlórien? What did mallorn-trees look like? And finally, how should we envision the herbs elanor and niphredil, and what made these two plants so sacred to the elves? Of course many additional questions come quickly to mind, and we deal with these in our book.

It is obvious from even a cursory reading of *The Lord of the Rings* that the book was written by a person who was botanically knowledgeable — but more than that — a writer who really loved plants! (In fact his introduction to the world of plants occurred very early in his life when he was taught botany by his mother.) But we don't need to merely accept this from our interpretations of his writings. Tolkien tells us of his appreciation of plants. He said in his letter to the Houghton Mifflin Co.: "I am (obviously) much in love with plants and above all trees, and always have been; and I find human maltreatment of them as hard to bear as some find ill-treatment of animals" (Tolkien, 1981: Letter No. 164). We agree: his love of plants is obvious, and it is apparent on nearly every page of *The Hobbit* or *The Lord of the Rings*. Only a writer whose eyes were open to the diversity of the natural world could have accomplished such

a task — closely integrating plants into his imagined world, and, as a result, including nearly all the trees of England (and also most European trees) within the Middle-earth of the First through the Third Ages. Because the species of trees (as well as shrubs and herbs) growing in England and other European regions are for the most part members of widely distributed genera that also occur in temperate North America and Asia, especially eastern and southeastern Asia, we can find the plants of Tolkien's Middle-earth in the forests and fields around our homes. Thus, a major goal of this book, in addition to increasing our appreciation of the imagined landscapes of Middle-earth, is to increase our respect for and understanding of the plants that grow in the natural environments that exist around us. Tolkien appreciated the beauty and diversity of the natural world, and its destruction through urbanization and industrialization angered him (unfortunately, modern followers of Saruman are not hard to find!). Thus, one of our goals is to increase the visibility of and love for plants in our modern culture. And, taking the Ents (*i.e.*, sentient trees, indwelt by spirits "summoned from afar"; *The Silmarillion*: p. 45) as our role-models, we hope to foster the desire to protect the forests and meadows near our homes (and across the world). Finally, the wild plants of forest and field are not our only concern. In our book we have also described the cultivated plants of vegetable and flower gardens as well as agricultural fields, addressing the interesting and long history of plants and people (or hobbits and elves!). We should appreciate not only wild plants (as do the Ents) but also the plants of orchards and cultivated fields (like the Entwives). In the end,

the fact that an investigation of the plants of Tolkien's Middle-earth reconnects us with the plants of our own world should not be surprising. Tolkien, in his essay *On Fairy-Stories*, said that "Recovery" is one of the goals of fantasy, and by this he meant "a re-gaining — regaining of a clear view" and "seeing things as we are (or were) meant to see them." Thus, in "experiencing the fantastic, we recover a fresh view of the unfantastic, a view too long dulled by familiarity" (Flieger, 2002: chapter 3).
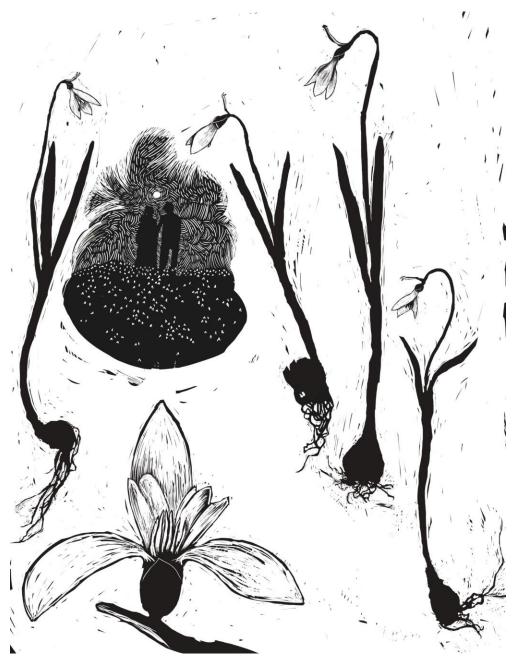
If the plants of Tolkien's legendarium are the trees, shrubs, and herbs of our own world, one might ask: What about plants such as elanor, niphredil, alfirin, simbelmynë, mallorn-trees, or the White Tree of Gondor? Are these simply the creation of Tolkien's imagination, or do they also have links to our own world. The answer, we think, is both — certainly these plants, as Tolkien explained, "are lit by a light that would not be seen ever in a growing plant" (Tolkien, 1981: Letter No. 312) in our world — so they arise, some more and others less, out of his imagination and are used in specific ways in the story in order to clarify aspects of elven, human, or hobbit culture. They are artistic creations, enhancing the wonder and mystery of Tolkien's imaginative world. But it is also important to keep in mind that perhaps all of the imaginative plants of Middle-earth are based, at least in part, on species of our own world. For example, Tolkien suggested that niphredil — if seen in the light of our world — would be "simply a delicate kin of a snowdrop," while elanor would be "a pimpernel (perhaps a little enlarged) growing sun-golden flowers and star-silver ones on the same plant" (Tolkien, 1981: Letter No. 312). As early as 1956, Tolkien commented that

"Botanists want a more accurate description of the mallorn, of elanor, niphredil, alfirin, mallos, and simbelmynë" (Tolkien, 1981: Letter No. 187), and we trust that many readers today have a similar desire. We have, therefore, done the necessary detective work to connect these imaginative plants with their sources and provide such accurate descriptions. We believe that this botanical knowledge will enrich the experience of those who have read (or are reading) Tolkien's works. Our book explores the interactions between plants and the speaking-peoples of Middle-earth — such as humans, hobbits, elves, or ents — whether such plants are the common oaks, pines, or grasses found in the sunlight of our world or are those plants lit by a more imaginative light, such as niphredil or elanor. Thus, we attempt in our book to synthesize information from diverse realms: Tolkien's writings, etymology (the evolution of words), botany and plant systematics (the study of plants and their evolutionary relationships), and artistic endeavors. We hope that Tolkien would approve of our attempt, as he suggested that the gold and silver light of Valinor, pouring from the Two Trees (Telperion and Laurelin), represents the "light of art undivorced from reason, that sees things both scientifically … and imaginatively" (Tolkien, 1981: Letter No. 131).

In the book we provide detailed treatments of the 141 plants of Middle-earth, and for each of the 100 most important plants of Tolkien's imaginative world, we include (1) the common and scientific names, along with an indication of the family to which the plant belongs; (2) a brief quote from one of Tolkien's works in which the plant is referenced; (3) a discussion of the significance of the plant in the context of

Tolkien's legendarium; (4) the etymology, relating to both the English common name and the Latin (or Latinized) scientific name, and where relevant, the name in one or more of the languages of Middle-earth; (5) a brief description of the plant's geographical distribution and ecology; (6) its economic importance; and (7) a brief description of the plant. Most of these also are provided with a woodcut-style illustration (as an aid to identification), along with an inset illustrating one of the events in the history of Middle-earth in which the plant played a role.

Niphredil (based upon the snowdrop, *Galanthus nivalis*, in the plant family Amaryllidaceae) with inset (vignette) showing Aragorn and Arwen on Cerin Amroth. Illustration from *Flora of Middle-Earth*.

It is our goal that the inset illustrations (vignettes) be functional, decorative, and fit visually into the lore of Middle Earth. By abstracting the images with a woodblock aesthetic, Graham, the second author and illustrator, was able to simplify the complexity of the plant pictured, providing a clearer view of the diagnostic features of each plant than a photograph would have offered. In his botanical illustrations, only the information needed to identify each plant is provided, and this same concept inspired his approach to the vignettes and narratives depicted. The tales and lore of Arda have been imagined by all of us, conceived and casted in movies, and depicted by talented and amazing artists. From the Hildebrandt brothers to Cor Blok, these artists and actors have shaded our original conceptions of what these characters, such as Bilbo or Gandalf, look like. Because of this we seek to create an abstracted view, offering silhouettes rife with symbols, pulling heavily on descriptions from the Tolkien's books to color our conceptualization of these well-fabricated characters. Keeping Tolkien's concerns in mind, we do not want to infringe on the viewer's ideation of the characters, but we feel it is very important to provide the framework for people to see the narrative, while still allowing them to project their own conceptualizations onto the image.

Traditionally, when we think of fantasy illustrations, we think of images framed like classic historical paintings or Greek dramas. By focusing on the flora over the fauna, we had to restructure how we approached the composition of each scene. So often plants are only the background that our grand actors stride across, but in contrast, we want to highlight how these narratives played out in the botanically rich and vibrant world that Tolkien imagined. This led Graham to a fundamental restructuring of the composition of each image, so the action or drama of the characters is often deemphasized, with the vignette focusing on how the action would have settled into the environment.

In conclusion, we hope that our book will create a visual reference — and legitimacy — for both the plants growing in our forests, meadows, and marshes, as well as those that we have received as gifts from Tolkien's imagination.

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History's first Easter egg

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Any gamer worth of his/her salt is well acquainted with the term "Easter egg". It designates any sort of secret message or feature (or even inside jokes) hidden in a video game or any other kind of software. The name is obviously based on the egg hunt game that many children enjoy during Easter.

Nowadays, Easter eggs are everywhere, having spread from games and computer software to comics, TV shows, and movies. Some would even argue that they have gone too far and that we have reached a point where Marvel's films have so many Easter eggs that they risk overtaking the main plot. Regardless, Easter eggs are something fun, that help to bring more color to any work, and are an important part of present pop culture; for instance, they are the very backbone of the novel *Ready Player One*. Thus, I would like to explore here the very first Easter egg in History. But first, let us see when the term was first applied.

ADVENTURE

The early history of video games is a little more dystopian than most would expect. Atari Inc. was one of the major names in the industry back in the 1970's. The games it developed and
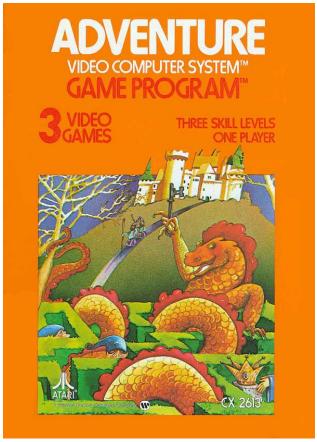
published were very influential, but changes in the company during the late 1970's led to some critical changes. Anonymity was to become the norm at Atari: programmers would not be credited in their creations anymore, for fear that rival companies would identify and "target" them, luring them away with higher salaries (and maybe a nicer working environment).

One of Atari's game developers, Joseph Warren Robinett Jr. (born 1951), was then working on a game called *Adventure* (released in 1979–1980). When Robinett heard that programmers would not be credited, he decided to credit himself in the game. He did so by hiding the message "Created by Warren Robinett" inside a secret room in the game. Or, in Robinett's own words:

"Atari would not give public credit to game designers. This was right after Atari had been acquired by Warner Communications. It was a power play to keep the game designers from getting recognition and therefore more bargaining power. So I created a secret room that was really hard to find, and hid my signature in it. I didn't tell anybody (this was a hard secret to keep to myself) and let Atari

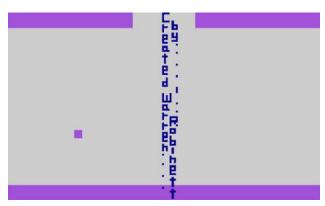manufacture a few hundred thousand cartridges and ship them around the world."
— Robinett (*in* Conelly, 2003).

Cover of *Adventure* for the Atari 2600. Image retrieved from MobyGames (http://www.mobygames.com/).

Robinett's secret room was indeed not easy to find: the player had to collect an invisible item in the castle (a 1-pixel object now known as "the Grey Dot") and use it to open a secret chamber deep in the catacombs. There, the player would find Robinett's message, written in flashing text.

After the game was released, Robinett kept his secret, but eventually an American teenager found the message and contacted Atari. The company at first thought of removing it, but this would be absurdly expensive. However,

Steve Wright, Atari's director of software development, had a moment of brilliant insight and pushed for the company to keep the message in the game. By his rationale, this hard-to-find secret would give players an extra reason to play the game, because it would be fun like Easter egg hunts. And just like that, the name "Easter egg" entered gaming culture: Atari decided to include Easter eggs in all their games and, by now, they have become a staple of the industry.

Screenshot of Robinett's Easter egg in *Adventure*. Image retrieved from Wikimedia Commons.

THE FIRST EASTER EGG

Despite Robinett's message being the one that gave rise to the name "Easter egg", it was not actually the first one we know of. The very first Easter egg in gaming history was only very recently discovered: the message "Hi, Ron!" in the arcade game *Starship 1* (Atari, 1977), programmed by Ron Milner.

However, given that many arcade games were released prior to *Starship 1*, it is very likely that even older Easter eggs might be found in the future. But they will not be as old as the very first Easter egg recorded in human History. For this, we need to travel some millennia back in time.

Flyer of *Starship 1*. Image retrieved from The Arcade Flyer Archive (http://flyers.arcade-museum.com).

UNCREDITED ARTISTS

Art in Ancient Egypt typically served religious or state purposes and very often, both of these realms were linked. Egyptian art was thus more functional than anything else and several artists were involved in the production of any single piece of art: from draftsmen and carvers to illustrators, painters, and scribes.

Like in Atari, these ancient artists worked in anonymity, never being credited. This was, however, the norm, and was not seen as an affront to an artist's creativity and personal work (as it was during the early days of video games). Even so, one[1] of these ancient artists

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[1] The only other artist credited in Ancient Egypt is Imhotep, vizier of Pharaoh Djoser (3rd Dynasty). Imhotep was responsible for building the first pyramid, the "Step

decided to credit himself. His name was Senenmut.

Statue of Senenmut (18th Dynasty, ca. 1470 BCE), held in the *Staatliches Museum Ägyptischer Kunst* (Munich, Germany). Photo by Vassil (2006); image retrieved from Wikimedia Commons.

ROYAL ARCHITECT

Senenmut was born a commoner, but in a literate family, which would put him in the upper 5% of the population. He entered the service of Queen Hatshepsut, of the 18th Dynasty, most likely when she was still the wife of Pharaoh Thutmose II. After the king's death, Hatshepsut became regent while Thutmose III
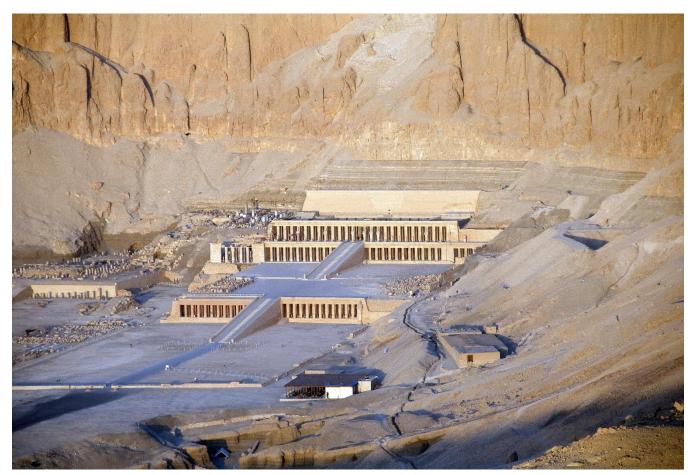

Pyramid" of Saqqara (2667–2648 BCE). Later, Imhotep was remembered as a great sage. Many centuries later, during the Late Period, he was worshipped as an actual deity, the patron of Medicine.

was still too young to rule the country. She then became *de facto* Pharaoh (even after Thutmose III reached adulthood) and ruled Egypt from circa 1478 to 1458 BCE.

Senenmut obviously gained importance during this time: he was the steward of Hatshepsut and the tutor of her daughter Neferure, a highly-regarded position. He worked as administrator of Hatshepsut's building projects and was also an astronomer and architect. Eventually, Senenmut would hold more than 80 titles, which included "Only friend of the Pharaoh". The obvious important position of Senenmut and this seeming favoritism led some archeologists (based more on hopeful gossip than actual scientific investigation) to imply he was Hatshepsut's lover.

As an architect, Senenmut's most remarkable project was Hatshepsut's mortuary temple at Deir el-Bahari (in ancient Thebes, modern Luxor), on the West bank of the Nile close to the Valley of the Kings. The temple, also known as "Djeser-Djeseru" ("Holy of Holies"), is one of Ancient Egypt's most beautiful buildings, designed in several different levels linked by ascending ramps, located against the cliff's face. It would have been even more awe-inspiring back in Hatshepsut's day, where a sphinx-lined causeway led visitors from the valley to its grandiose entrance, marked by large pylons.

Mortuary temple of Hatshepsut. Photo by W. Hagens (2010); image retrieved from Wikimedia Commons.

The curious thing is that, going against the practice of all prior (and later) Egyptian artists and craftsmen, Senenmut decided to sign his *magnum opus*. He hid his signature behind one of the temple's main doors: his name and an image of himself.

Senenmut's signature: a relief with his image and name.

We will never know why Senenmut decided to do this, but we can imagine that, given how remarkable a building the mortuary temple is, anyone would feel inclined to get recognition for it. So there you go, when Robinett decided to hide his own signature in a castle's secret chamber, little did he know that a precedent had already been set 3,500 years ago: Senenmut's Easter egg (not that Easter was already a thing back then, but you get the idea).

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Dr. **Rodrigo Salvador** is a zoologist/paleontologist and was trying really hard to write something more biologically inclined. Instead, he ended up writing his third consecutive article about Ancient Egypt. And now he will be off playing *Assassin's Creed Origins*.