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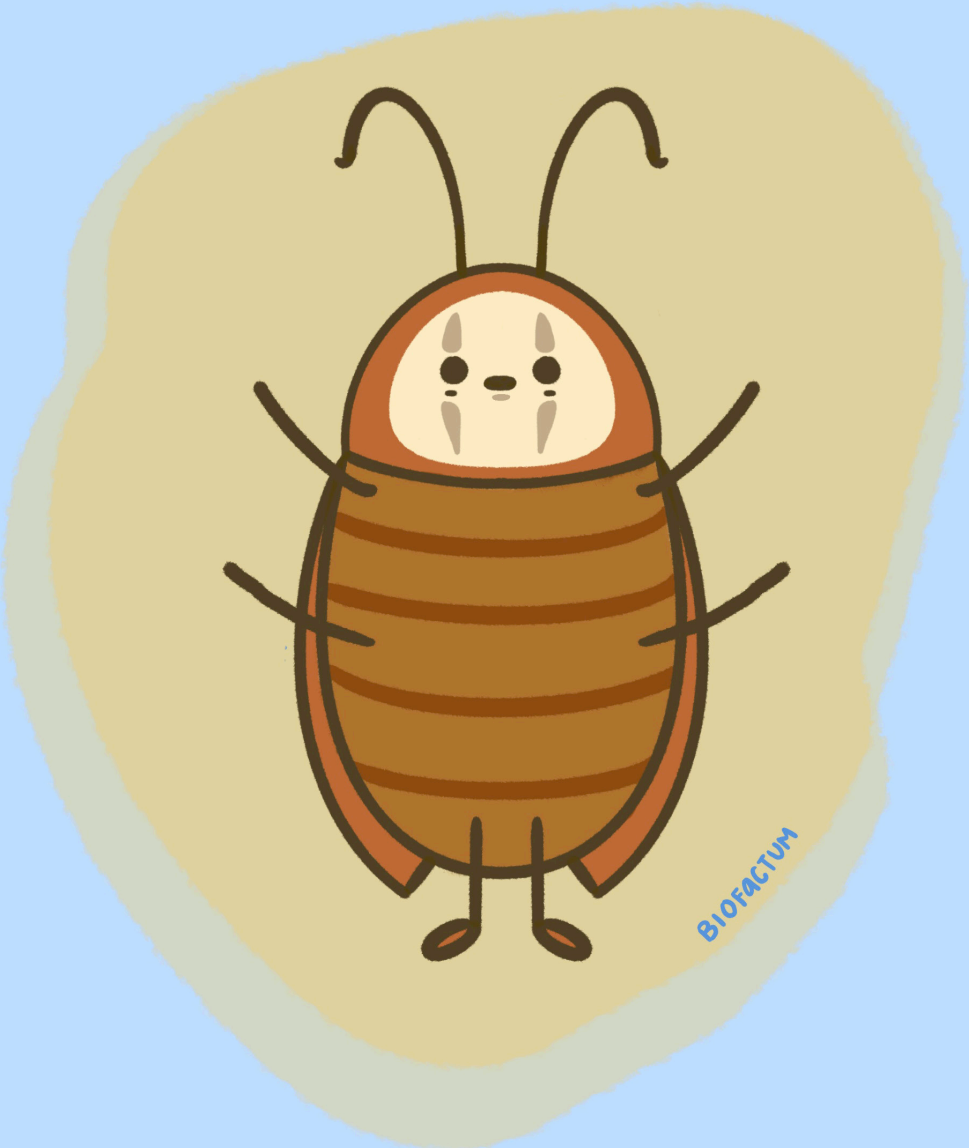

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Cover art: The No-Face cockroach *Cretaperiplaneta kaonashi* **(artwork by Karla J. Humara-Gil).**

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Gundam Plastic Model Kit consumer spending in Indonesia

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The market dynamic of Gundam Plastic Model Kits, Gunpla for short, has changed since the producer's business strategy shifted to achieve more growth outside of the Japan Domestic Market. One of the signs of this strategy shifting is that now, Bandai Namco broadcasts the *Gundam* series, both the old series or newer series on the same day as Japan, on the gundam.info YouTube channel that can be accessed by people outside Japan.

The author would like to assess the market dynamic of Gunpla in Indonesia through the lenses of several factors in the marketing mix. The assessment of the situation is done by collecting primary data through a market survey and secondary data from the Internet and market observation.

GUNDAM PLASTIC MODEL KITS

Gunpla is produced by Bandai (through Bandai Spirits) since 1980 and it is popular among mecha anime (anime featuring robots) fans and model enthusiasts around the world. Well-known lineups of Gunpla for collectors nowadays can be seen in the table below.

Bandai always announces its upcoming products several months before the release date. After the announcement, people can pre-order from their favorite retailers. For Premium Bandai exclusive products, the order can be done through the Premium Bandai website.

Table 1. Gunpla scale, grades, and height. There are some other line-ups such as Mega Size or Universal Century Hard Graph but we didn't include them in the table since they are not that popular.

Scale	Grades	Height (approx.)
Non-scale	Super Deformed	3 inches
1/144	High Grade, Entry Grade, Real Grade	4–5 inches
1/100	Master Grade, Full Mechanic	7 inches
1/60	Perfect Grade	15 inches

DISCUSSION

We will discuss Indonesian Gunpla consumers through some of the components of 7Ps Marketing Mix (Charted Institute of Marketing, 2015), which are Products, Price, Place, and Promotion. We will also discuss what Gunpla collectors in Indonesia collect other than Gunpla.

To understand consumer spending, we did a survey in February 2023 with 400 people through some Gundam-related Facebook groups in Indonesia, like Gundam Community Indonesia, Gundam Nusantara Indonesia, and Mecha Hujatposting Indonesia. 400 samples satisfy the need to have a confidence level of 95% that the real value is within ±5% of the surveyed value. Even so, there are some limitations, since surveys are prone to sampling bias, state preference bias, or question framing bias. The survey and summarized results can be found in the Appendix.

Product

Gunpla is well known for its quality and easiness to build. It is this quality advantage that makes Gunpla more easily accepted by the market. The products come with the parts in plastic sprue, manual, and box package with illustration and model explanation on it. The design of the Gunpla is based on the mecha that appeared in the *Mobile Suit Gundam* series. Depending on the grade, the design could be similar to the series or have certain modifications either in proportion, details, or added gimmicks.

From our survey, 98% of the sample stated that they buy a Gunpla because of the design of the kit. Even so, 32.75% stated that faithfulness to the source material is not the reason they buy the kit. This could be anticipated by Bandai since some grades like Master Grade do redesign and give more gimmicks (sliding parts, added joint, more panel lines) to the kit. For newer kits, the design usually has more panel lines than how the character appeared in the source material. For comparison, 1/100 Gundam Barbatos and Master Grade Gundam Barbatos have different proportions, engineering aspects, panel lines, and prices despite having the same scale (Fig. 1).

Figure 1. Comparison of 1/100 Gundam Barbatos and MG Gundam Barbatos, extracted from dalong.net (http://dalong.net/).

Price

As imported goods, we analyze how the price can be explained with

$$P^{Japan} + Cost = P^{Indonesia}$$

where the price of Gunpla in Indonesia is the price of Gunpla in Japan plus added costs (i.e., import, customs, and tax). We compare some prices of items in different conditions, which are pre-order and ready stock, since it is normal in the market to have differences in price for pre-order and ready stock.

We compare the ready stock price of SD EX Gundam Aerial, High Grade Gundam Aerial, and High Grade Shenlong Gundam that were released in September–October 2022. All of them arrived in Indonesia around the end of 2022. To add more comparison, I also included FM Forbidden Gundam, available for pre-order in the end of March 2023. The exchange rate we used for the SD EX Gundam Aerial, HG Gun-

Table 2. Price comparison between MSRP in JPY (*excluding tax) and IDR.

Kit Name	MSRP in JPY*	MSRP in IRD	Price from official distributor in IDR	Conversion rate
SD EX Gundam Aerial	600	68,154	120,000	200
HG Gundam Aerial	1,300	147,667	260,000	200
HG Shenlong Gundam	1,500	170,385	247,500	165
FM Forbidden Gundam pre-order	5,800	677,382	754,000	130

dam Aerial, and HG Shenlong Gundam is the rate on Dec 1st 2022 (JPY/IDR @115.39), while for FM Forbidden Gundam pre-order we used the rate on March 20th 2023 (JPY/IDR @116.79). The comparison can be seen in Table 2.

The variation of conversion rate is different between pre-order price, the ready stock price for regular items with a high level of popularity, and the ready stock price for items with low-to-mid popularity. Price differences between ready stock and pre-order items are considered normal while the price differences between highly popular and low-to-mid-popularity items is debatable.

For Premium Bandai Gunpla, since there is no access to Premium Bandai in Indonesia, consumers can get Premium Bandai Gunpla from resellers in Indonesia. The price is approximated at a 200 conversion rate or higher. For example, Master Grade Gundam Stormbringer with a Yen price of JPY 5,400 is sold in Indonesia at IDR 1,350,000.

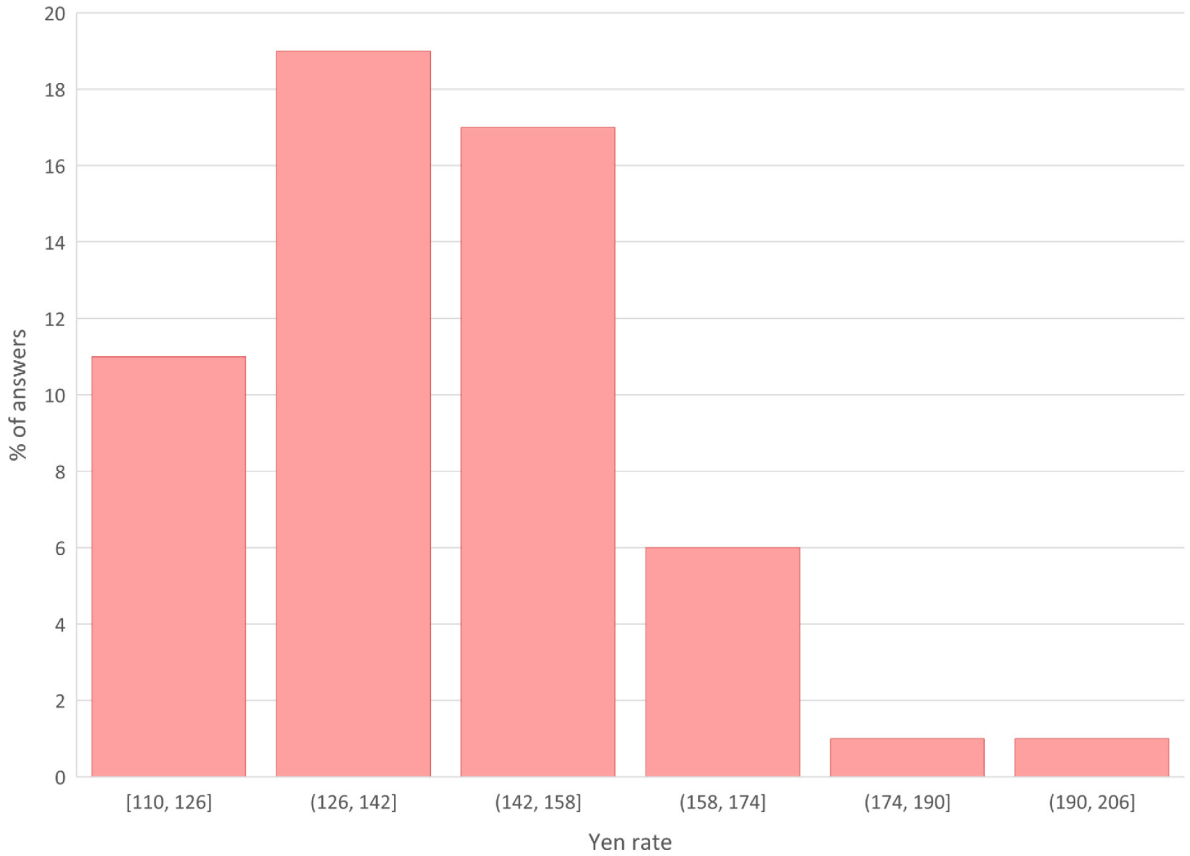

Figure 2. Histogram of conversion rate willingness to pay for popular regular Gunpla.

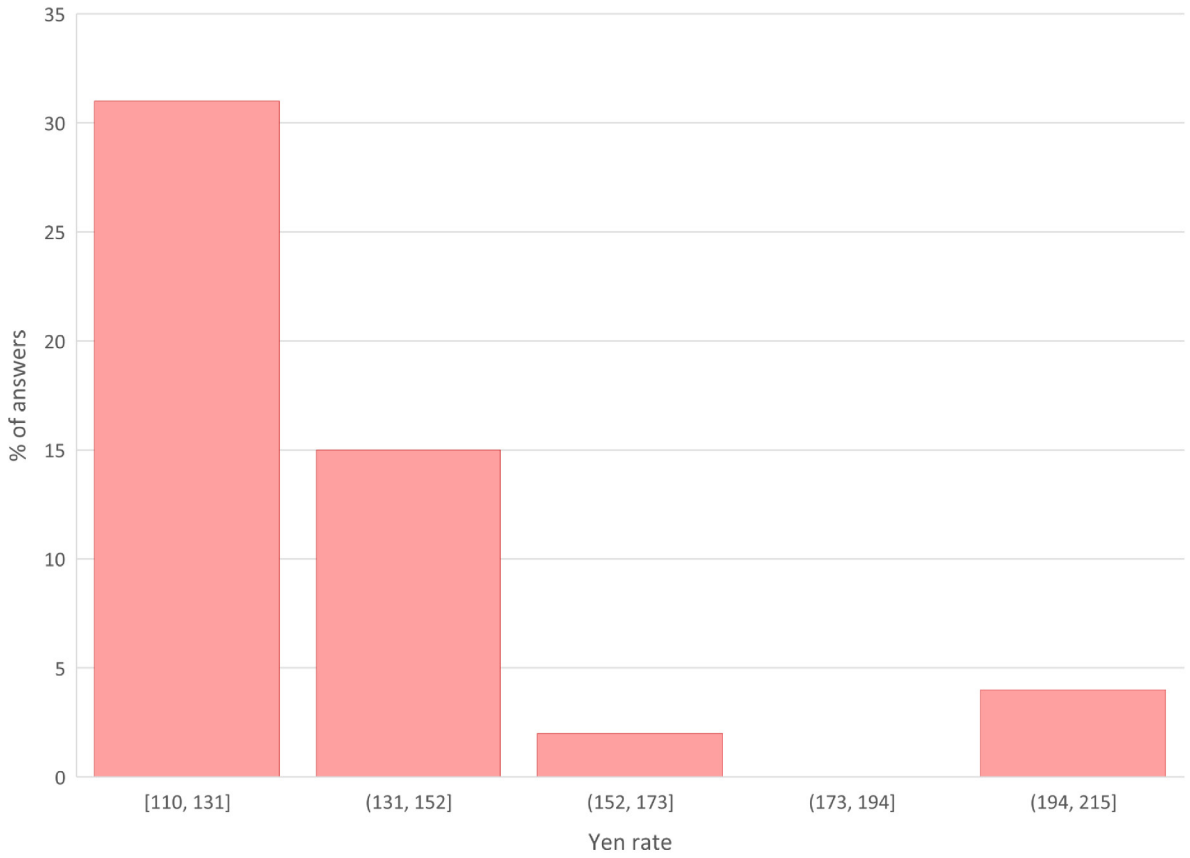

Figure 3. Histogram of conversion rate willingness to pay for normal regular Gunpla.

We collected data on how much it is the conversion rate people are willing to pay for three item categories, which are regular-popular, regular-normal, and limited. The histograms are shown in Figures 2 to 4. From the data, there is a bit mismatch between the willingness to pay and the retail price in Indonesia. Looking at the current market conditions, Gunpla sales are mostly helped by the popular ones (main character units) rather than by those that are not really popular (grunt units or antagonist units). Not everyone is familiar with the JPY price of Gunpla but eventually, they will learn after some time.

One unique phenomenon in the Indonesian market is that there is a "By Air" price for regular Gunplas that arrive in Indonesia approximately one month after release in Japan. The conversion rate of the price is about the same with limited Gunpla. This price difference occurs because there are extra costs borne from importing the goods by the sellers. This phenomenon occurred because normally through the official channels, Gunpla arrive in Indonesia about three months after released in Japan.

While cheaper line-ups like High Grade and Entry Grade are intended to create a low entry barrier for newcomers, the price level cannot be considered low in Indonesia. From CEIC data, the monthly earnings of Indonesia in 2022 is USD 192 (around IDR 2.8 million), very low compared to Japan (USD 2,122). This income level itself is already a challenge to sell a large quantity of Gunpla and might be a problem since Gunpla creates profits through a large number of sales.

Place

Consumers can buy Gunpla products from sellers through online marketplaces such as Tokopedia or Shopee, social media platforms, or in physical stores. The price between sellers varies. Some people can

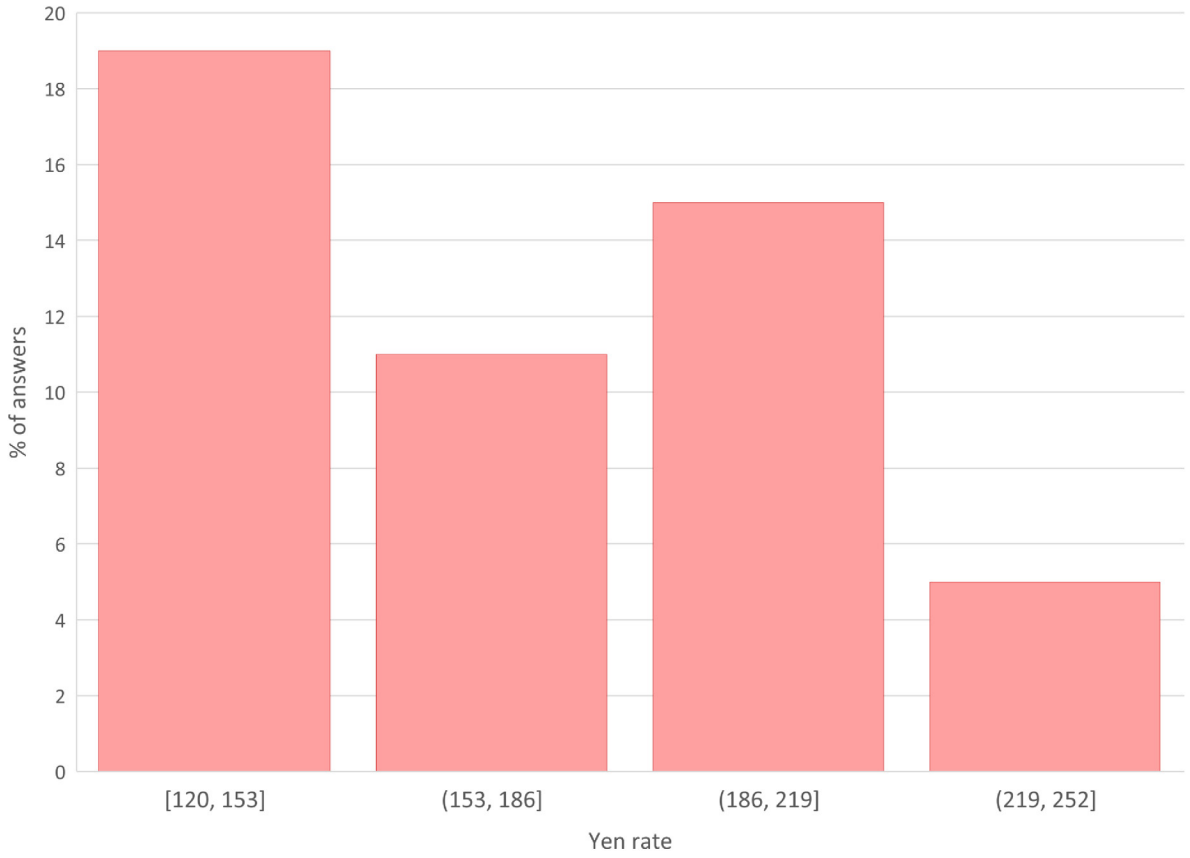

Figure 4. Histogram of conversion rate willingness to pay for limited Gunpla.

import Gunpla by themselves, but the price will be around the "By Air" price mentioned above.

Promotion

Bandai promotes Gunpla products for people outside of Japan through their social media and gundam.info YouTube channel. For new items showcase, Bandai also collaborates with local distributor Multi Toys in Indonesia to run events like Pop-up stores, Gundam Builders World Cup, or dedicated booths in toys fair events. In some events, usually, there are discounts to boost sales.

Other collections

We would like to discuss other toys that Gunpla consumers collect since some of them, in this case bootlegs, are a threat to Gunpla. Also, understanding other lineups give us a better understanding of consumers' preferences for other hobbies in the Gunpla community. We divided the respondents according to how they earn their income, i.e., still earn it from their parents or are already financially independent. The result is shown in Table 3.

Consumers divide third-party products into four categories. They are: (1) copies of the original, as in directly using the mold of original Gunplas; (2) modified copies of the original, where the original Gunpla is released by Bandai but with different details; (3) characters that are not yet released by Bandai; and (4) just the add-ons. Third-party products for Gunpla are not licensed by Bandai and can be a threat due to their lower prices in comparison. This has been anticipated by Bandai by setting a fairly cheap price for the High Grade kits, which are intended for newcomers.

Table 3. Other collectibles owned by respondents, according to whether they have own income or are dependent on a parent or guardian.

Items	Dependent	Independent	All
Vehicles Model Kits	13.51%	11.35%	11.75%
Military Model Kits	6.76%	7.98%	7.75%
Diecast	29.73%	24.85%	25.75%
Mokit Mecha non-Bandai	28.38%	31.29%	30.75%
Figma	14.86%	15.34%	15.25%
Nendoroid	18.92%	13.50%	14.50%
GundamUniverse	13.51%	9.20%	10.00%
Robot Damashii	10.81%	14.72%	14.00%
S.H.Figuarts	17.57%	20.55%	20.00%
Metal Build / Metal Structure	1.35%	14.11%	11.75%
Chogokin	4.05%	9.20%	8.25%
Statue	6.76%	11.35%	10.50%
Scale Figure	21.62%	19.33%	19.75%

CONCLUSION

While Bandai as Gunpla producer already widens its promotion to overseas markets, including Indonesia, we found a mismatch between the Gunpla retail prices and consumers' willingness to buy in Indonesia. This mismatch is plausibly bad news for Gunpla producer and local distributor since Gunpla relies on a high volume of sales to generate profit. Relying on discounts, especially when the hype is already down, is not a good business practice. This mismatch also paved the way for third-party products since their prices are lower and the intended newcomers, which are high school students, do not really have a high willingness to pay for third-party products. This condition can be mitigated by doing adjustments to the price level of Gunpla products so that sales volume can be increased and maintain sustainable business practices in Indonesia.

In future studies, it will be important to consider factors such as demand price elasticity and marginal costs of production to validate the hypothesis. These factors play a crucial role in understanding the dynamics of the market and assessing the feasibility and viability of the proposed hypothesis. It is also important to study the shelf life of the Gunpla hobby and the possibility of switching hobbies or collections in the community to gain more insight into purchasing behavior.

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About the author

Zetra Iez Zaputra is a Bachelor of Management alumni from a certain campus in Bandung, Indonesia. In his free time, he builds Gunpla, takes pictures of his toys, watches anime, or browses online marketplaces to find additions to his collections.

APPENDIX: Survey questions and summary of answers

Demographics of the respondents

1. Tingkat pendidikan terakhir. (Education level.)

Elementary School (0)

Junior High School (3)

Senior High School (117)

Diploma 1 (4)

Diploma 2 (0)

Diploma 3 (25)

Diploma 4 (3)

Bachelor (215)

Masters (31)

PhD (1)

2. Apakah Anda berpenghasilan sendiri atau masih menjadi tanggungan? (Do you have your own income or are you still a dependent?)

Independent (326)

Dependent on parent/guardian (74)

3. Rata-rata pendapatan Anda per bulan. (Your average monthly income.)

<IDR 500,000 (44)

Between IDR 500,000 – 1 million (34)

Between IDR 1 – 3 million (95)

Between IDR 3 – 5 million (71)

Between IDR 5 – 7 million (49)

Between IDR 7 – 10 million (47)

Between IDR 10 – 15 million (28)

> IDR 15 million (32)

4. Apakah anda sudah berkeluarga? (Are you married?)

Yes (133)

No (267)

5. Region tempat tinggal Anda? (What region do you live in?)

Bali dan Nusa Tenggara (11)

Kalimantan (22)

Jawa (332)

Overseas (3)

Papua (1)

Sulawesi (9)

Sumatera (22)

Purchasing Behavior

1. Berapa rata-rata pengeluaran Anda untuk membeli Gunpla dalam sebulan dalam Rupiah? (How much do you spend on average to buy Gunpla in a month, stated in IDR?)

Median (IRD 500,000)

Q1 (IRD 300,000)

Q3 (IRD 1,000,000)

Lowest (IRD 50,000)

Largest (IRD 50,000,000)

2. Apakah Anda selalu menonton film / membaca komik dari Gunpla yang Anda beli? (Do you always watch films / read comics of Gunpla that you buy?)

Yes (61.5%)

No (38.5%)

3. Apakah desain Gunpla menjadi salah satu daya tarik dari Gunpla yang Anda beli? (Is the Gunpla design one of the appeals of the Gunpla you buy?)

Yes (98%)

No (2%)

4. Apakah popularitas Gunpla menjadi salah satu daya tarik dari Gunpla yang Anda beli? (Is the popularity of Gunpla one of the appeals of the Gunpla you buy?)

Yes (40.75%)

No (59.25%)

5. Apakah kesesuaian Gunpla dengan yang muncul di media (film/komik/novel/dll) menjadi salah satu daya tarik dari Gunpla yang Anda beli? (Is Gunpla's faithfulness with what appears in the media (movies/comics/novels/etc.) one of the appeals of the Gunpla you buy?)

Yes (67.25%)

No (32.75%)

6. Bagaimana desain kit menurut Anda? (How important is the kit's design for you?)

Very not important (1.00%)

Not important (0.75%)

Important (16.00%)

Very important (82.25%)

7. Bagaimana kepopuleran kit menurut Anda? (How important is thekit's popularity for you?)

Very not important (14.00%)

Not important (59.25%)

Important (21.75%)

Very important (5.00%)

8. Bagaimana kesesuaian kit dengan di media sumber menurut Anda? (How important is the kit's faithfulness to source media for you?)

Very not important (6.25%)

Not important (42.00%)

Important (35.25%)

Very important (16.50%)

9. Bagaimana ukuran kit menurut Anda? (How important is the kit's size for you?)

Very not important (4.50%)

Not important (30.75%)

Important (41.75%)

Very important (23.00%)

10. Untuk barang reguler yang populer, berapa rate dari harga yen paling tinggi untuk Anda beli? Rate JPY-IDR BCA per 3 Februari 2023 adalah Rp115,68/Yen. (For popular regular items, what is the highest Yen rate for you to buy? BCA's JPY-IDR rate as of 3 February 2023 is IDR 115.68/JPY.)

See Figure 2.

11. Untuk barang reguler yang tidak populer, berapa rate dari harga yen paling tinggi untuk Anda beli? Rate JPY-IDR BCA per 3 Februari 2023 adalah Rp115,68/Yen. (For unpopular regular items, what is the highest Yen rate for you to buy? BCA's

JPY-IDR rate as of 3 February 2023 is IDR 115.68/JPY.)

See Figure 3.

12. Untuk barang limited, berapa rate dari harga yen paling tinggi untuk Anda beli? Rate JPY-IDR BCA per 3 Februari 2023 adalah Rp115,68/Yen. (For limited items, what is the highest Yen rate for you to buy? BCA's JPY-IDR rate as of 3 February 2023 is IDR 115.68/JPY.)

See Figure 4.

13. Apakah Anda mengoleksi produk 3rd party? (Do you collect third-party products?)

Yes, different detail with existing (31.25%)

Yes, copy of the existing kit (26.25%)

Yes, no existing kit (23.25%)

Yes, add-on (23.50%)

No (41.00%)

14. Lini mainan apa saja yang Anda koleksi selain Gunpla? (What other toy lines do you collect besides Gunpla?)

Vehicles Model Kits (11.75%)

Military Model Kits (7.75%)

Diecast (25.75%)

Mokit Mecha non-Bandai (30.75%)

Figma (15.25%)

Nendoroid (14.50%)

GundamUniverse (10.00%)

Robot Damashii (14.00%)

S.H.Figuarts (20.00%)

Metal Build / Metal Structure (11.75%)

Chogokin (8.25%)

Statue (10.50%)

Scale Figure (19.75%)

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An unexpected bird in *Honkai: Star Rail* and China's war on sparrows

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In April 2023, the gacha game *Honkai: Star Rail* was launched, published by miHoYo/HoYoverse, a Chinese company now very famous for its hit game Genshin Impact. The game is a space opera focusing on a group of interstellar adventurers that travels across the universe to eliminate dangerous artifacts known as Stellarons. The player builds their team with a variety of anime-style characters (23 in total as of writing) earned from a brutal[1] gacha mechanic.

So far, *Star Rail* has followed a similar recipe to Genshin Impact: the first world is based on Europe and the second one in China. In the Chinese-inspired Xianzhou Luofu, you run across a character called Sushang[2]. There's not much of note about this character per se, except that in her Ultimate she summons a giant chicken. That is already fantastic on its own, but when a character uses their Ultimate, the player can also see their splash art (Fig. 1).

Sushang's splash art immediately caught my eye, because it features birds – more specifically, tree sparrows (Fig. 2). And, as Sushang is a Chinese-inspired character, my first thought was "Well, that's odd." because modern China has a dark history with tree sparrows.

Actually, let me put that correctly: the Chinese government, and Mao Zedong in particular, has a horrid history with sparrows in what is probably the world's most unnecessary ecological tragedy. It is a tragedy so big that it could and should be used exhaustively as a cautionary tale in any environmental arguments made today – and yet, it isn't. Instead, China's war on birds remains largely unknown, which I find rather odd. So, I decided to write a bit about it. I promise that I will come back to games in the end of this article, but first we will take a closer look at the birds and at China's folly.

Figure 1. Sushang's splash art. Source: Honkai: Star Rail Wiki (https://honkai-star-rail.fandom.com/).

[1] And I play FGO!

[2] Though you can get her in the regular gacha before that.

Figure 2. Close-up of Fig. 1 showing the tree sparrows.

MEET THE TREE SPARROW

The tree sparrow is a nice little bird recognizable from other sparrow species by the black markings on its "cheeks" (Fig. 3). Males and females look alike in this species, contrary to what is the rule in other species of sparrows (Clement et al., 1993). These birds build their nests in cavities in trees, rocks, and buildings. When establishing their nests, they might choose to do so in close proximity to other sparrows, forming a loose type of colony (Hegyi & Sasvári, 1994; Summers-Smith, 1995). Tree sparrows feed on seeds and grain throughout the year, but will also capture small invertebrates, particularly when they are feeding their young (Summers-Smith, 1995, 2016).

Figure 3. A tree sparrow photographed in Osaka, Japan. This bird species, as many passerines, has the potential to be classified as birbs, borbs, and floofs (cf. Elbein, 2019, 2020). Source: Wikimedia Commons (Laitche, 2015; CC-BY-SA 4.0), image cropped.

The tree sparrow is thought to have originated in Asia, potentially in China, around 5 million years ago (Summers-Smith, 1995; Päckert et al., 2021). Today, it is a widespread species across Eurasia and some of the Atlantic and Pacific Islands, and it has been introduced to countries like Australia, the Philippines, and the USA (Summers-Smith, 1988, 1995, 2016). Its scientific name is Passer montanus but that is misleading, because these birds do not typically live on the mountains. In Europe, it is a rural species preferring more natural habitats, while the house sparrow (Passer domesticus) is an urban species. In Asia, it is the other way around: the house sparrow sticks to more natural areas while the tree sparrow is urban.

Both tree sparrows and house sparrows evolved alongside humans to become our commensals (Summers-Smith, 1988, 1995). They have adapted to live in our settlements, villages, and now cities. This was studied in greater depth in house sparrows, in which thicker skulls and a greater capacity to digest starch is linked to a diet based on grains (Ravinet et al., 2018). The grains that people cultivate.

THE FOUR PESTS CAMPAIGN

Only three countries in the entire world were foolish enough to wage war against birds: Australia, China, and the USA. They all lost – miserably so.

Australia lost a war to the emu and the US lost to house sparrows. The former is a rather amusing story, so I recommend you look it up. The latter has a dark undertone, as the attack on house sparrows was filled with racist and xenophobic connotations creating a parallel between the introduced birds and the new waves of immigrants then arriving in the US (Fine & Christoforides, 1991). But we are not interested in those stories here, so let us get back to China, who – as you might have guessed by now – went to war against tree sparrows (麻雀).

The Great Leap Forward was a social and economic campaign established by Chairman Mao Zedong during 1958–1962. One of its first actions was a great leap for-

ward into the abyss: the so-called Four Pests campaign (Fig. 4). The goal of the campaign was to exterminate disease vectors (rats, flies, mosquitoes) and sparrows. The latter was obviously not a disease vector, but was thought to eat too much of the grain produced in China. The actual accusation was that each sparrow ate around 1.8 kg of grain per year (Time, 1958).

Figure 4. Official government propaganda poster "Exterminate the four pests!" (1958). Source: Chinese Posters (https://chineseposters.net/).

As one of China's greatest environmental activists, Dai Qing, said "Mao knew nothing about animals. He didn't want to discuss his plan or listen to experts. He just decided that the 'four pests' should be killed" (Luard, 2004). Typical. One of his main slogans was "Man can conquer nature" (Shapiro, 2009; Steinfeld, 2015).

Mao's government then bombarded its people with collectivist slogans, pseudo-scientific rhetoric, and propaganda posters (Fig. 5), inciting citizens to take up arms against the pests (Sun, 2017). They encouraged people to band together in task forces or "sanitation teams" and kill each and every single pest they found (Sun, 2017). To deal with the sparrows, people shot or slingshot them, set traps, and climbed on trees (including during the night) to strangle the birds, break their eggs, and destroy their nests. People would also station themselves on roofs and under trees, constantly waving flags, beating drums, and clanging pots and pans to terrorize the sparrows (Fig. 6). The noise and commotion prevented the birds from landing, forcing them to keep flying around and eventually making them die of exhaustion.

Figure 5. Official government propaganda posters. Left: "Everybody comes to beat sparrows" (1956). Center: "Let nobody disturb him" (1956). Right: "Eliminating the last sparrow" (1959). Source: Chinese Posters (https://chineseposters.net/).

It is impossible to say how many birds were killed during that time (Fig. 7). In three days, an estimate of 800,000 sparrows were killed in Beijing alone (Han, 1959). Thus, it is expected that several hundreds of millions were killed country-wide (McCarthy, 2010).[3]

[3] When a species is a target of extermination like this, it is common that other species that are similar-looking are also killed by mistake. In this case, it would be the house sparrows (*Passer domesticus*) and the cinnamon sparrows (or russet sparrows, *Passer cinnamomeus*) which also live in China (Clement et al., 1993) – not to mention other birds of similar size like finches, etc., which were likely also caught in the "crossfire". However, I could not find any information about that.

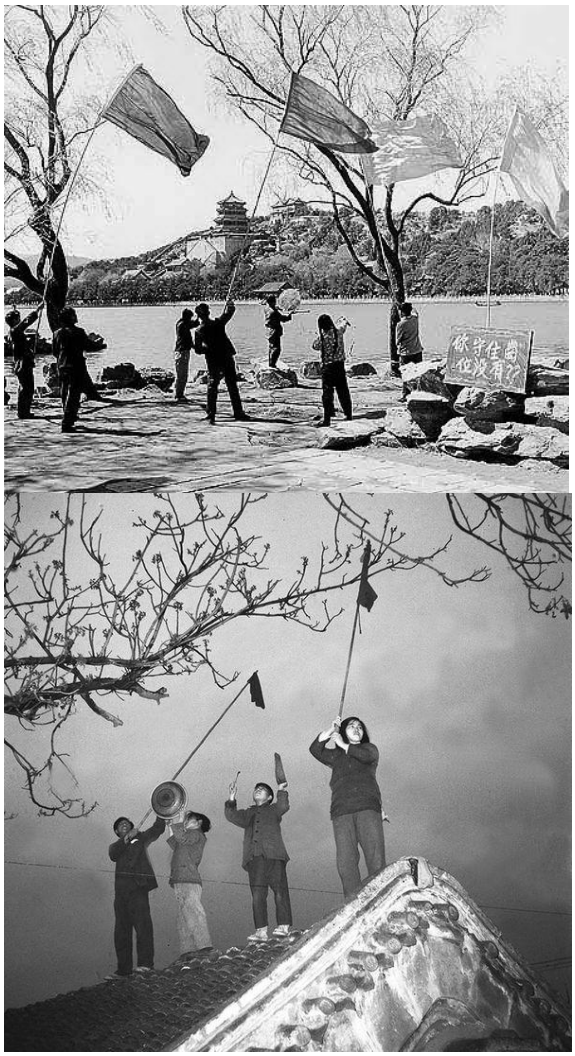

Figure 6. People killing sparrows (and undoubtedly other unrelated birds as well) by exhaustion. Source: Sohu (https://www.sohu.com/).

As a result, the tree sparrow was driven almost to extinction in China (Summers-Smith, 1995; Dvorsky, 2012). "But wait a second, didn't you say that China lost the war against the sparrows?" Well… call it karma, divine punishment, science, or ecology, it does not matter. There was instant retribution.

In the following year, 1959, the number of insects (notably locusts) infesting and destroying the crops exploded. The already problematic agricultural system in China was dealt a major – and fatal – blow (McCarthy, 2010). The failing crops led to the Great Famine, which would kill millions of people.

Figure 7. A cart full of dead sparrows. Source: Sohu (https://www.sohu.com/).

SCIENCE & VINDICATION

When the Four Pests campaign was announced, ornithologists (scientists who study birds) in China tried to have a say in the matter. Chief among them was Tso-hsin Cheng (1906–1998; often transcribed as Zheng Zuoxin) from the Chinese Academy of Sciences Zoology Research Institute, who realized the government (and many people) were blinded by prejudice against sparrows. He argued – correctly – that serious studies were necessary before such hardline extermination policies were put into practice (Zhang, 2019).

Cheng repeatedly asked the government to reconsider the inclusion of sparrows in the Four Pests campaign, but to no avail (Zhang, 2019). As he (1) was a scientist, and (2) directly opposed Mao's policies, he was declared a criminal, forced to wear a badge that read "reactionary", subjected to "re-education" through manual labour (sweeping floors, cleaning toilets, etc.), had his salary reduced to a bare minimum, was arrested for a time, and exposed to public mockery in a literal sense (Nowak, 2002). He was even told by the authorities that "birds are Capitalism's pets" (Nowak, 2002), which has got to be one of the most ridiculous lines any scientist has ever heard.

Still, Cheng led a team on the first thorough study on tree sparrows in China. By studying stomach content of birds from across China, they showed that while sparrows did eat grain, they also (and mostly)

ate insects, playing a major role in controlling the number of the insects that were actual agricultural pests, like the locusts (Beer, 2019). It became clear then that killing the sparrows led to an explosion in the numbers of insects, who found themselves with virtually no predator and hence free to do as they pleased. That, in turn, was a key factor leading to what is now regarded as the worst famine in History.[4]

With more than enough proof on his side, Cheng continued to advocate through newspaper articles and seminars (Zhang, 2019). Finally, after the near-extinction of the sparrows in China the government capitulated and the sparrows were removed from the Four Pests in 1960, being substituted by bed bugs.[5] In the years that followed, China even imported sparrows from Russia to boost the populations of the species inside its borders (Townshend, 2015). But then it was already too late: the damage was done and the death toll of the famine, which lasted from 1959 to 1961, was around 36 million people.[6]

The Great Famine is still kind of taboo in China. Elsewhere, the ecological causes of it are (understandably) put in second place after the human loss and suffering of the era. Sometimes, however, the ecological factor is not even considered; for instance, most purely economic models and assessments about the time do not even seem to know that birds and insects exist (e.g., Li & Yang, 2005; Wang, 2015).

In any event, as I noted before, a self-inflicted ecological catastrophe of this magnitude, with millions dying because of a poor decision of a political leader, should be more often used as an example against all the dangerous environmental policies (or lack thereof) we continue to see. The take-home message is evident, as Steinfeld (2018) put it "ignore science at your peril." Case in point, China's recent Zero Covid policy and its early-2000's SARS policy have both been considered a failure to learn from the great sparrow debacle and a repetition of the Four Pests mistakes (Luard, 2004; Reddy, 2022).[7]

But there is at least some sort of silver lining for the birds. After the tragedy, people not only did a one-eighty in their stance towards the tree sparrows but also started to have a higher appreciation for bird conservation in general (Obermann, 2021). When China was deciding on a national bird, the tree sparrow was one of the main contenders against the leading red-crowned crane. The sparrow was considered by many to better represent the people, while the crane was perceived as an "elite" bird (Canaves, 2008).[8] Moreover, tree sparrows are now

[4]While the ecological imbalance was the major immediate cause, there were other factors contributing to the famine such as faked harvest numbers, maintenance of high export quotas, a shortage of workers, and the indifference of the government towards its people's hardships and suffering (Dikötter, 2010).

[5] Despite all the troubles he went through, Cheng is reported to have deeply loved his work and the Chinese bird fauna (Hsu, 1999; Nowak, 2002; Ward & Chen, 2017). He published his landmark work "Distributional List of Chinese Birds" in 1978 (though it's dated 1976) and went on to become the father of modern ornithology in China (Grimm, 1977; Zhang, 2019). Later on, in 1987, he published the monumental "A Synopsis of the Avifauna of China". Cheng was also responsible for rebuilding the bridges between Chinese ornithologists and the global scientific community after the end of the Cultural Revolution in China (Hsu, 1999; Nowak, 2002).

[6] The estimates of the famine's death toll vary quite a lot. The largest number that officials have admitted to is 20 million, but Yang Jisheng, who studied documents of the period in China proposed the number 36 million (Jisheng, 2012). However, others still consider that to be a quite conservative estimate and have proposed instead around 43 to 46 million (Dikötter, 2010). In comparison, the Covid pandemic has killed around 7 million people according to the World Health Organization (https://covid19.who.int/; but again, an underestimate).

[7] China is not alone in that, as the nightmarish Covid policies (or lack thereof) of countries like the USA and Brazil clearly exemplify. Not to mention the ecological and environmental disasters in those countries and in others.

[8]Ironically, China's national bird, the red-crowned crane is also known as Japanese crane (its scientific name is *Grus japonensis*). This fact was pointed out at the time by Chinese authorities who were against the idea (Beijing News, 2008).

Figure 8. 写生珍禽图 [Sketches of Rare Birds], by Huang Quan. The tree sparrows can be seen to the right, showing a natural behaviour: the young bird is asking its parent for food. Source: Wikimedia Commons (public domain).

Figure 9. *Morning Sparrows and Young Peony*, by Keinen Imao, 1891. Keinen specialized in kachō-e and naturalistic details (notice the life-like behaviour of this host of sparrows). Source: Ronin Gallery (https://www.roningallery.com/) (public domain).

a protected species in China and it is prohibited by law to kill, eat, or sell them, and killing more than 20 is treated as a criminal offense (Sun, 2017). So modern instances of 'sparrowcide' often make the news in China because they evoke painful reminders of the Four Pests campaign and the Great Famine (Sun, 2017).

SUZUME

It is hard to say why tree sparrows were used in Sushang's splash art in *Star Rail* because there is not much material available out there about things like character creation processes and artistic choices in the game. It might be a natural choice because, as mentioned above, the tree sparrows are now well regarded in China. In fact, they have had a marked presence in Chinese art for centuries before Mao started his crusade against them (Summers-Smith, 1995). That tradition stretches back to at least the Five Dynasties period, when Huang Quan (903–965) developed a more naturalistic style of painting birds and became one of the founders of bird-and-flower painting (huaniaohua, 花鸟画) (Yu, 2023). An example of one of his paintings containing tree sparrows can be seen in Figure 8.

However, HoYoverse's games lean heavily on the anime aesthetic, so the sparrows in Sushang's splash art could have a Japanese influence behind them as well. After all, these birds (スズメ, 'suzume') are much more common in Japanese stuff. As in China, they are also present in art – likely even more prominently so. Bird-and-flower painting arrived a few centuries later in Japan and evolved into its particular style. When the era of ukiyo-e woodblock printing started, bird-and-flower paintings (then known as kachō-e, 花鳥絵) became very widespread and tree sparrows were commonly featured (Fig. 9). Today, they appear everywhere in anime/manga and Japanese games as well (Fig. 10) – now that you know what these birds look like, try and keep an eye out for them.

Like for many other animal species, and birds in particular, not all is well for tree sparrows. In the past fifty years, there has been a sharp decline in their numbers in Europe, although the species is not considered endangered yet (Field & Anderson, 2004). The same decline might be happening in Asia as well, in large part due to relentless urbanization (e.g., Mikami, 2009; Zhang & Zheng, 2010). Researchers are now calling for better urban planning with greener cities that can support our urban wildlife (Zhang et al., 2008; Schilthuizen, 2018).

Figure 10. Examples of tree sparrows in another gacha game, *Fate/Grand Order*: final ascension artwork of the characters Beni-Enma (illustrated by Harada Takehito) and Sei Shounagon (illustrated by Mika Pikazo). Beni-Enma is based on the Japanese fable "The Tongue-Cut Sparrow". Source: Fate/Grand Order Wiki (https://fategrandorder.fandom.com/).

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About the author

Dr **Rodrigo B. Salvador** is a biologist specialized in the study of snails, though he sometimes does research on birds as well. Tree and house sparrows are among his favourite birds and he has a small collection of suzume-related items from Japan, from gacha capsule toys to more artistic ones. He is enjoying *Star Rail* so far, but he doesn't use Sushang in his lineup – perhaps if her Ultimate was a giant sparrow instead of a chicken…

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Unleashing the Alien: a deep dive into the terrifying world of Xenomorphs in science fiction and horror

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The Xenomorph is an iconic extraterrestrial creature that has captivated audiences in the realm of science fiction. Known for its menacing appearance and deadly nature, the Xenomorph has become a symbol of terror and has left an indelible mark on popular culture. Ridley Scott's 1979 film *Alien* introduced this mysterious creature for the first time. Since then, it has emerged as a key character in the franchise and inspired numerous sequels, spin-offs, and adaptations. The term originates from the Greek words *xenos* that can be translated as 'stranger' or 'foreigner' and *morphḗ*, which can be translated as 'form'. Therefore, one may think of a xenomorph as an "alien-shaped thing". The species is seldom referred to by the term xenomorph in the films. They are more often referred to as aliens, things, them, or it. The moniker xenomorph continues to be around despite the disapproval of certain fans and the designers' initial intentions (Marsh et al., 1978).

Throughout its history in science fiction and horror, the Xenomorph has undergone various adaptations and evolutions. The franchise expanded with sequels, prequels, and spin-offs, delving deeper into the Xenomorph's origins, biology, and its interactions with human characters. The creature's life cycle, from the Facehugger stage to the fully-grown, nightmarish form, adds an additional layer of terror and suspense.

Figure 1. Alien movie poster (1979). Image extracted from IMDb (https://www.imdb.com/).

The Xenomorph's impact extends beyond the silver screen. It has made appearances in comics, video games, literature, and other forms of media, further cement-

ing its status as a cultural phenomenon. The creature's ability to tap into humanity's primal fears, its relentless pursuit of its prey, and its highly adaptive and lethal nature have made it a popular antagonist in various storytelling mediums (Roza, 2015). The Xenomorph has influenced and inspired countless filmmakers, writers, artists, and creators within the science fiction and horror genres (Constable, 1999). Its unique design, the legacy of H.R. Giger's artistic vision, has become instantly recognizable and iconic, serving as a benchmark for monstrous and terrifying creatures in popular culture (Rockoff, 2011). As a result, the Xenomorph has garnered a devoted fan community that continues to celebrate and explore the creature's mythology, dissecting its symbolism, and engaging in discussions about its place within the broader context of science fiction and horror (Vermaak, 2019). Generally, the Xenomorph's presence in science fiction and horror is a testament to its enduring impact. It stands as a chilling embodiment of the unknown and a reminder of our vulnerability in the face of the alien and the monstrous and its legacy as a fearsome and iconic creature continues to resonate with audiences, ensuring its place in the annals of science fiction and horror history (Barkman & Tokbergenova, 2017).

CONCEPT AND DESIGN

The design of the Xenomorph is both fascinating and horrifying, a product of the creative vision of Swiss artist H.R. Giger. Giger's unique artistic style, characterized by dark, biomechanical forms and sexual overtones, played a pivotal role in shaping the distinctive look of the creature (Škrgić, 2017). The Xenomorph is a biomechanical organism, blending elements of an insect and a reptile with mechanical features. Its elongated head features a large, elongated cranium, a ridged skull, and a menacing, elongated jawline filled with razor-sharp teeth. The creature's sleek, elongated body is adorned with a smooth, exoskeletal-like surface, accentuated by a glossy black coloration. It possesses a long, whip-like tail that aids in balance and serves as a formidable weapon (Újvári, 2018).

Figure 2. Giger's original Alien design (Xenomorph). Image extracted from Wikimedia Commons (H.R Giger, 1979).

The Xenomorph's most distinctive feature is its elongated, retractable inner jaw, commonly referred to as the "Xenomorph's second mouth" or the "inner mouth". This appendage, which extends from within the creature's mouth, is equipped with sharp teeth and is capable of delivering a fatal strike to its victims. This additional mouth adds an extra layer of horror and unpredictability to the Xenomorph's attacks (Cruz, 2012).

Giger's influence extended beyond the Xenomorph itself. His conceptual art and designs for the film also shaped the overall

visual aesthetic of the *Alien* universe. The haunting and atmospheric environments, as well as the intricate spacecraft and alien architecture, all bear his signature style, contributing to the eerie and otherworldly atmosphere of the films (Roberts, 2006). Giger's contributions to the *Alien* franchise earned him an Academy Award for Best Achievement in Visual Effects in 1979. His work on the Xenomorph and *Alien* also secured his place as one of the most visionary and influential artists in the realm of science fiction and horror (Škrgić, 2017). His legacy lives on not only through the enduring popularity of the Xenomorph but also through the profound impact on his art has had on the broader art community (Glick, 2017; Conway, 2017).

Figure 3. H. R. Giger at work on the *Alien* figure for Alien (1979). Image extracted from BFI (https://www2.bfi.org.uk/news-opinion/news-bfi/features/hr-gigers-alien-in-pictures).

THE XENOMORPH'S HISTORY

The Xenomorph's history in science fiction is a fascinating journey that spans multiple films, expanding the creature's lore and adding layers of complexity to its terrifying nature. Since its debut in the 1979 film *Alien* the Xenomorph has evolved into a seminal figure in the genre, captivating audiences and leaving an indelible mark on science fiction and horror storytelling (Muir, 2013). In *Alien*, the crew of the Nostromo spacecraft encounters a derelict alien vessel and unwittingly brings back a lethal organism known as a Facehugger. This creature implants an embryo into one of the crewmembers, which later erupts as a fully-grown Xenomorph, setting the stage for a relentless and nightmarish pursuit.

The success of *Alien* paved the way for sequels, each expanding the Xenomorph's mythology and introducing new facets of its terrifying existence. James Cameron's 1986 sequel, *Aliens*, shifted the focus to a group of heavily armed marines facing off against a horde of Xenomorphs on a colonized planet. This film further highlighted the Xenomorph's adaptability, hive mentality, and the inclusion of a queen, deepening the creature's hierarchy and social structure. Subsequent sequels, such as *Alien 3* (1992) and *Alien: Resurrection* (1997) explored different narrative directions and introduced variations of the Xenomorph, including genetic experiments and hybrid creatures. These installments delved into the themes of genetic manipulation and cloning, adding a new layer of complexity to the Xenomorph's origins and emphasizing its status as a bioengineered nightmare (Conway, 2017).

The franchise also expanded through prequels, starting with *Prometheus* in 2012 and followed by *Alien: Covenant* in 2017. These films delved into the backstory of the Xenomorph and the Engineers, the alien race responsible for its creation. They explored themes of creation, artificial intelligence, and the pursuit of immortality, expanding the philosophical and existential dimensions of the Xenomorph's existence (Addey, 2018).

The Xenomorph's impact extends beyond the film franchise, permeating other media forms. It has appeared in comics, video games, and literature, allowing fans to further explore and engage with the creature's mythology. These adaptations have provided new narratives, expanded universes, and additional encounters with the Xenomorph, further cementing its status as a menacing force in science fiction (Melzer, 2010). The Xenomorph's enduring appeal lies in its primal and visceral qualities; its deadly lifecycle, stealthy behavior, and relentless pursuit of prey tap into humanity's instinctual fears of being hunted and

overpowered. Its iconic design has become synonymous with extraterrestrial terror, inspiring countless filmmakers and artists and setting the standard for monstrous creatures in the genre (Melzer, 2006). The Xenomorph's evolution in science fiction is a testament to its enduring impact. From its origins in Alien to its expansion through sequels, prequels, and adaptations, the Xenomorph has become an iconic figure that embodies fear, unpredictability, and the unknown. Its history in science fiction continues to fascinate and terrify audiences, solidifying its place as one of the most memorable and terrifying creatures in the genre's history (Roberts, 2010).

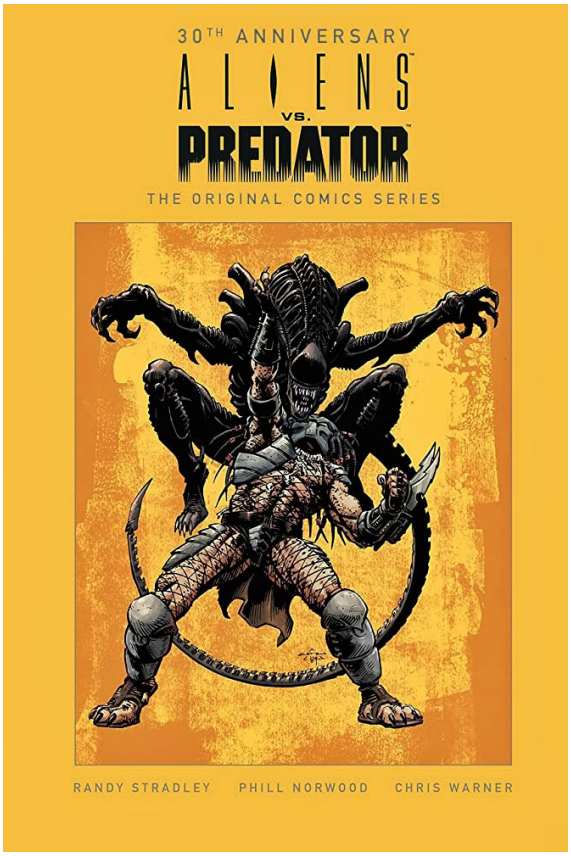

Figure 4. *Aliens vs. Predator: The Original Comics Series* (30th Anniversary Edition). Image extracted from Amazon (https://www.amazon.com/).

Comics have provided a fertile ground for the Xenomorph's expansion. Numerous comic book series have been published featuring the creature, delving into its origins, encounters with other characters and species, and its ongoing pursuit of prey. Notably, Dark Horse Comics has been instrumental in bringing the Xenomorph to the pages of comic books, with titles like *Aliens* (1988–1989), *Aliens vs. Predator* (1989–2020), and *Aliens: Colonial Marines* (1993–1994). These comics have expanded the lore of the Xenomorph and its interactions with other iconic characters, creating rich and interconnected storylines.

Video games have also embraced the Xenomorph, translating its terror and suspense into interactive experiences. From first-person shooters to survival horror games, the Xenomorph has been featured as a formidable and relentless adversary, challenging players to navigate dangerous environments while being hunted by the creature. Games such as *Alien: Isolation* (Creative Assembly, 2014) have garnered critical acclaim for their atmospheric storytelling, intense gameplay, and faithful depiction of the Xenomorph's characteristics and behavior (Sloan, 2016).

Figure 5. Cover art for the *Alien: Isolation* video game (Xbox One version). Image extracted from Sega (https://www.sega.com/).

Literature has provided yet another avenue for the Xenomorph's expansion and exploration. Numerous novels and novelizations have been written, expanding upon

the creature's mythology and offering new narratives within the *Alien* universe. These books often delve into the Xenomorph's origins, its encounters with different characters, and the broader implications of its existence. Authors like Alan Dean Foster, Tim Lebbon, and James A. Moore have contributed to the literary expansion of the Xenomorph, offering fans a deeper understanding of the creature and its world.

The presence of the Xenomorph in these different media forms has allowed for a multi-dimensional exploration of the creature's mythology. Each adaptation brings a unique perspective and adds to the broader narrative tapestry, enriching the overall understanding of the Xenomorph's origins, behavior, and impact. These adaptations also offer fans the opportunity to immerse themselves in the Xenomorph's world, further fueling their fascination with the creature and the terror it embodies. Moreover, the Xenomorph's adaptation into comics, video games, and literature has expanded its reach to wider audiences, extending its cultural impact beyond the confines of film (Burke, 2015). It has inspired fan communities, cosplayers, and creative fan works, fostering a sense of collective engagement and appreciation for the Xenomorph across different forms of media (Csicsery-Ronay, 2007).

LIFE CYCLE AND BEHAVIOR

The Xenomorph possesses a unique and horrifying life cycle that contributes to its terrifying nature. The life cycle begins with the Facehugger, a parasitic creature that attaches itself to a host organism, typically a human. The Facehugger implants an embryo into the host's body, which eventually grows and incubates within the host, remaining hidden until it bursts forth in a violent and gory birth. This initial stage of the life cycle sets the tone for the Xenomorph's parasitic nature and its ability to exploit and manipulate other life forms for its own survival (Fleury & Mamber, 2019).

After emerging from a host, the Xenomorph gains its fully-grown form, characterized by its sleek and biomechanical appearance, as described above. It is a highly adaptive predator, capable of surviving in various environments, be it the confined spaces of a spacecraft or the vastness of an alien world. The creature's behavior is marked by its relentless pursuit of prey; it is a cunning and patient hunter, utilizing stealth, agility, and its acute senses to track down its victims (Littau, 2011). It possesses an uncanny ability to blend into its surroundings, making it a formidable opponent that strikes without warning (Csicsery-Ronay, 2007). The Xenomorph displays a degree of intelligence, demonstrating problem-solving skills and a capacity for learning, making it an even more formidable adversary (Gordon, 2018).

Once the Xenomorph captures a victim, it can use them as a host for the next generation of Facehuggers, perpetuating its life cycle. This parasitic reproductive strategy adds an additional layer of horror and heightens the sense of dread associated with the Xenomorph (DiGioia, 2021).

Furthermore, the Xenomorph exhibits a hive-like social structure, with a queen at the apex. The queen is responsible for laying eggs and overseeing the reproductive cycle of the species. This hierarchical organization showcases the Xenomorph's ability to function as a collective and work together to defend the hive and expand its population. The Xenomorph's anatomical features and behaviors have become iconic, representing the epitome of a relentless and lethal predator within the realm of science fiction (Csicsery-Ronay, 2007).

CULTURAL IMPACT AND LEGACY

The Xenomorph's cultural impact and legacy can be observed through various avenues, including its influence on film, art, fashion, and the broader science fiction genre. First and foremost, it has become synonymous with extraterrestrial terror and its iconic appearance has inspired countless filmmakers, artists, and creature designers,

shaping the visual landscape of science fiction and horror cinema (Fleury & Mamber, 2019).

The original 1979 film revolutionized the portrayal of space horror, introducing a gritty and atmospheric tone that captivated audiences (Glick, 2018). Subsequent films in the series, along with spin-offs and prequels, have further expanded the Xenomorph's mythology and cemented its status as a cultural touchstone, extending beyond cinema to other forms of media and merchandise, as explored above.

In addition, the Xenomorph's influence can be seen even in the world of art and fashion. The creature's biomechanical design and haunting aesthetic have inspired artists and designers to incorporate elements of the Xenomorph into their works (Gilmore, 2015). Its influence can be found in sculptures , paintings , and even fashion collections , highlighting the creature's enduring appeal and its ability to resonate with creative minds across different disciplines (Efland, 1976).

The Xenomorph's cultural impact is also reflected in its status as a pop culture icon and as a symbol of horror, fear, and the unknown. The creature's image is often referenced and parodied in various forms of media, appearing in cartoons, memes, and other pop culture references. The Xenomorph has become part of the collective consciousness, recognized by audiences worldwide, even those who may not have seen the original films (O'Sullivan, 2010).

Moreover, the Xenomorph's legacy can be observed through its enduring popularity and its ability to transcend generations. The *Alien* franchise continues to captivate audiences, with new installments and spin-offs keeping the Xenomorph's terrifying presence alive. The creature's cultural impact has already spanned four decades, resonating with fans old and new, and ensuring its place as one of the most iconic and feared creatures in the science fiction and horror genres.

As long as the realms of science fiction and horror exist, the Xenomorph's legacy will endure, forever etching its place in the annals of popular culture (Gordon, 2018; Koenig-Woodyard et al., 2018).

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Dark wings, bright insights: a comprehensive analysis of corvid species in *Pokémon* games

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O crow,

why are you flying from here

to the noisy town?

(Matsuo Bashō's haiku, English interpretation by Dmitri Smirnov)

Birds have been part of the human collective and incorporated as symbols in religion, art, science, and daily life across many cultures and time periods (Elphick, 2005). Because of their undeniable visual and acoustic beauty, remarkable abilities, and conspicuous presence in numerous different environments, these winged creatures often inspire and intrigue the human mind (Robinson, 2019). There are thousands of avian species in the world, taxonomically classified into many groups. Still, when it comes to intelligent and alluring birds, few can rival the captivating nature of corvids (Emery, 2006). The Corvidae family is composed of 23 genera and 128 species spreading across most regions of the world, including the birds commonly known as crows, ravens, jays, and magpies (Winkler et al., 2020).

The bond between people and corvids extends beyond the attention received for their curious behaviors. Their cognitive abilities enable them to problem-solve, exhibiting complex social cognition, memory, and even tool use (Emery, 2004). Approximately 25% of the corvid species have demonstrated the ability to adapt to human-modified environments (Benmazouz, 2021), thriving on the resources offered by these habitats. As many of these species are omnivorous, it is not uncommon that crows incorporate human-made foods into their regular diet, whether raiding overflowing trash cans (García-Arroyo et al., 2023), munching on roadkill (Schwartz et al., 2018), or stealing snacks from unsuspecting people and pets. Because of the remarkable capacity of corvids to coexist within cities, suburbs, farmlands, landfills, and even industrial landscapes, they have also established themselves as a ubiquitous presence in our everyday lives (Marzluff & Angell, 2007).

From ancient American civilizations to Asian folklore and European traditions, many corvid species – but particularly crows and ravens – have inspired myths and legends, becoming fascinating characters woven into the fabric of those cultural narratives (Król & Hernik, 2020). Crows have been considered bad omens related to the occult, evil, and death, particularly in Western-European beliefs: portrayed as familiars of witches (i.e., creatures or spirits summoned by a witch, usually to carry out tasks; Murray, 2008), depicted as feasting on the corpses of the fallen at the battle and thus associated to the devastating loss of life (Marzluff & Angell, 2007), or simply linked to the forthcoming of unfortunate events in fictional texts (Soares et al., 2019), they earned the collective nouns of "murder" and "unkindness" for crows and ra-

vens respectively.

However, the cultural depictions of corvids are not limited to negative connotations alone, with crows revered for their intelligence often being associated with qualities such as cleverness, resourcefulness, and adaptability. In many American indigenous cultures, corvids are seen as wise and cunning creatures, displaying remarkable problem-solving skills (Taylor, 2014). Similarly, in Norse mythology, crows were central to Odin as he used them to learn about the world: Muninn ['memory'] and Huginn ['thought'] (Marzluff & Angell, 2007).

In East Asian cultures, these animals are a symbol of filial gratitude and solar elements associated with leadership (Knode, 2003). Especially in Japanese folklore, corvids have been adopted into different representations and meanings. Yatagarasu (八咫烏; 'eight-span crow') was a giant three-legged crow kami (god) that guided the first emperor; this mythical figure continues to endure, even being adopted as the emblem of the Japanese national soccer team (Molle, 2011). Likewise, in Ainu legends, crows play a vital role in saving people. These legends speak of crows retrieving the Sun after it was swallowed by a monstrous creature, as well as guiding the starving Ainu to a stranded whale for them to be saved (Ashkenazi, 2003).

Considering both the positive and negative cultural representations of corvids, it is not strange to find them still as part of modern literature, music, cinema, and video games. Such depictions occur in *Pokémon*, a media franchise with games focused on the exploration of areas to catch and train creatures (i.e., species of Pokémon) to battle against other trainers. The design of

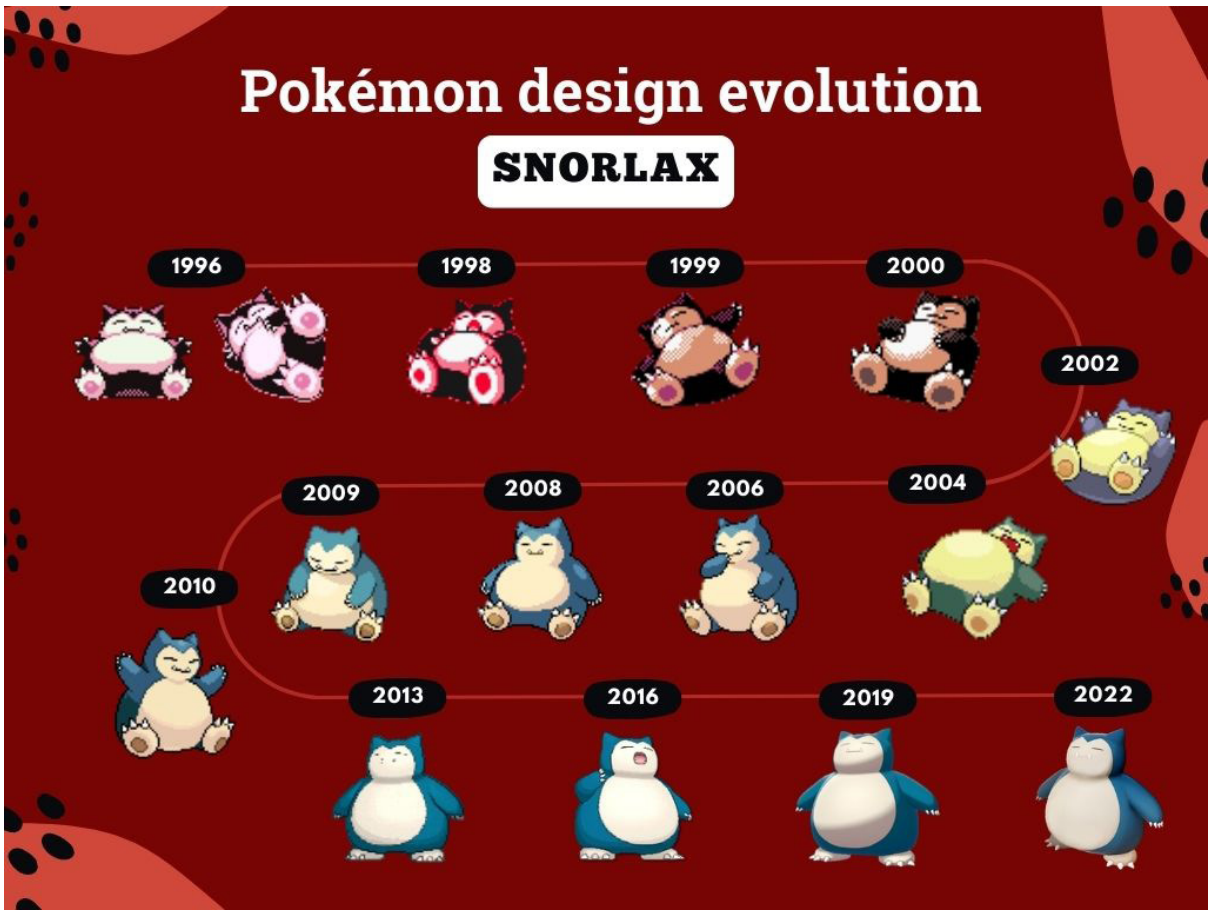

Figure 1. Timeline of the evolution of designs of Pokémon sprites using Snorlax as an example. It is possible to appreciate differences in colors and resolution improvement from the first 2D sprites to the 3D models featured in the most recent games. This figure also shows how it took 17 years for Snorlax to finally stand up. The Pokémon sprites are official artwork from the franchise (©Nintendo/Game Freak, 1995–2023).

each Pokémon species is based on different kinds of animals, plants, fungi, unicellular organisms, mythological creatures, and/or a mix of inanimate objects. Many of them are accurately depicted with high detail and their lore is based on the biology, behavior, or characteristics parallel to their actual counterparts in the real world (Mendes et al., 2017; Prado & Almeida, 2017; Kittel, 2018; Rosa et al., 2020; Carral-Murrieta et al., 2023).

Because of the above, we consider that *Pokémon* possess a huge potential to describe and explain natural science subjects in an accessible, enjoyable manner that transcends cultural and/or academic barriers. For this article, we assessed the Pokémon species based on or related to corvids. We analyzed their names in English and Japanese, and Pokédex entries to find references related to real-world species involved in the design and describe the cultural connections with their real-world counterparts.

CROWVOLUTION OF CORVID POKÉMON

The designs of Pokémon have continued to evolve in the franchise over the years, starting with simple sprites for Generation I, mainly due to the graphic limitations of the console in which the game was first released (launched for Game Boy in 1996). However, with time and new features and capacities of the following consoles, the designs started to include colored sprites (*Pokémon Sapphire/Ruby* for Game Boy Advance in 2002), animated sprites (*Pokémon Diamond/Pearl* for Nintendo DS in 2006), and 3D models (*Pokémon X/Y* for Nintendo 3DS in 2014). The subsequent graphic improvements have allowed the inclusion of more detailed designs and more realistic Pokémon species (Fig. 1).

The increase in Pokémon diversity has also made possible the expansion of lore about the Pokémon world concerning characters, regions, and even species variation. In the games, the information about Pokémon species is recorded as entries in a hand-held, electronic encyclopedia called Pokédex. Entries on the Pokédex have changed with time and vary between games and generations, with some of them being remarkably accurate concerning the biology of both the Pokémon and the organism that it is based on. Additionally, Pokémon species names are available in more than one language (e.g., Japanese, English, French, German, Korean), which also provides clues about the identity of real-world organisms and objects that served as inspiration for the designs. Taking into account all these elements, we aim to identify the bird species or combination of species that served as inspiration for the design of the five corvid Pokémon.

Murkrow

First included in *Pokémon Gold/Silver* (1999), the English name Murkrow is most likely a combination of the words '**murder**' and '**crow**' referring to the collective noun for crows and the animal itself respectively. Regarding the Japanese version of the name (ヤミカラス, Yamikarasu) results from the combination of the words '**yami**' (dark) and '**karasu**' (crow). This allusion to darkness can also be derived from the word '**murk**' also meaning "darkness that hinders vision" (Cambridge Dictionary, 2023).

Murkrow's design derives partially from a carrion crow (*Corvus corone*), a widely distributed species in Europe and Central Asia that is also abundant in Japanese cities (Brazil, 2018; BirdLife International, 2023). In this context, we find another parallelism between Murkrow and the carrion crow as Johto (i.e., Generation II location) is based on the Kansai region of Japan, located in the southern-central region of the main island (Bulbapedia, 2023). While the appearance matches in shape and color, the characteristic yellow bill and feet are more commonly found in other corvid species such as the yellow-billed chough (*Pyrrhocorax graculus*) (Fig. 2).

On the other hand, the head feathers resemble a classical witch hat while the tail takes the shape of a broom, alluding to the

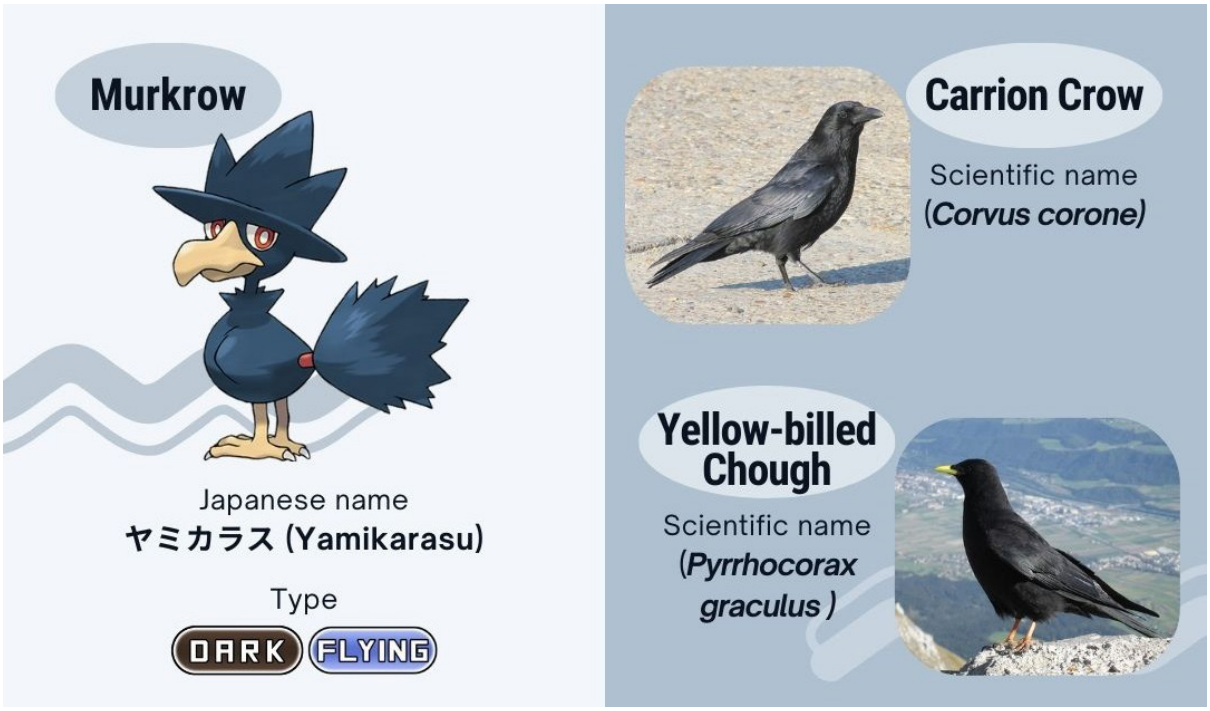

Figure 2. Official artwork of Murkrow (©Nintendo/Game Freak, 1995–2023), introduced in Generation II. The right panel shows the hypothesized inspiration species, the carrion crow (D. Davison; Wikimedia Commons, CC BY 2.0) and the yellow-billed chough (Mbdortmund; Wikimedia Commons, CC BY-SA 3.0).

image of a witch on a broomstick flight from the Western-European folklore. Some Pokédex entries refer to these traits, like the one included in *Gold* ("*Feared and loathed by many, it is believed to bring misfortune to all those who see it at night*"); this entry refers to the belief that some animals such as crows and black cats are bad omens because of their association with witchcraft (Nyakupfuka, 2012). This is consistent with Murkrow's dual type (Dark/Flying) and category (Darkness Pokémon), with some of its moves representing malicious activities and mischievousness (e.g., Taunt, Foul Play, Sucker Punch, Torment, Thief; Bulbapedia, 2023).

A subsequent Pokédex entry from *Ruby/Sapphire* (2002) reads: "*This Pokémon shows strong interest in anything that sparkles or glitters. It will even try to steal rings from women*", referring to the popular notion that corvids collect shiny objects. However, there is no scientific evidence that supports this idea, and could actually be a misinterpretation of the explorative behavior of corvids (Greenberg, 2003). The attraction of crows to shiny objects can be explained by neophilia (i.e., spontaneous attraction of an animal to novel food items, objects, and places) that allows young birds to explore novel habitats and find different types of resources (Heinrich, 1995).

Honchkrow

The evolution of Murkrow first appeared with the launch of *Diamond/Pearl* (2006). This Pokémon's English name is a combination of the words '**honcho**' used to refer to a person in charge (e.g., a boss; Cambridge Dictionary, 2023) and '**crow**' spelled in the same way as its unevolved counterpart. Similarly, the Japanese version name (ドンカラス, Donkarasu) uses the word '**don**' which is an honorific prefix that was popularized in the USA to refer to the highest ranks in the mafia hierarchy (Devico, 2007), and '**karasu**' (crow). This deviates from the previous association with darkness and places this Pokémon in its unique category of "Big Boss Pokémon" (Bulbapedia, 2023). Honchkrow has some characteristics of a crime boss, such as fedora-shaped head feathers and a plumage pattern resembling an elegant suit.

Figure 3. Official artwork of Honchkrow (©Nintendo/Game Freak, 1995–2023), introduced in Generation IV. The right panel shows two of the hypothesized inspiration species, the Daurian jackdaw (C. Moning; Wikimedia Commons, CC BY-SA 4.0) and the large-billed crow (Alpsdake; Wikimedia Commons, CC BY-SA 4.0).

According to Bulbapedia (2023), Honchkrow's coloration is similar to that of a hooded crow (*Corvus cornix*); however, on closer inspection, the pattern on the breast of the animal does not match the white on Honchkrow's design. Instead, we consider that this coloration pattern resembles more that of the Daurian jackdaw (*Coloeus dauuricus*) a rare winter visitor in Nansei Shoto north to Hokkaido (Brazil, 2018). We also considered the large-billed crow (*Corvus macrorhynchos*) as an inspiration species because of its sharpened bill, curved on the tip (Fig. 3). Additionally, the coloration of Honchkrow slightly resembles the dark blue metallic sheen present in the flight feathers of the adult birds (Matsubara, 2007). The distribution of both species extends to or near Hokkaido (Brazil, 2018; BirdLife International, 2023), being consistent with the Honchkrow distribution in Sinnoh, a region of the Pokémon world inspired by the geography of Hokkaido (Bulbapedia, 2023).

An interesting Pokédex entry from *Diamond* describes Honchkrow as follows: "*Becoming active at night, it is known to swarm with numerous Murkrow in town*". From an ecological perspective, this entry refers to a mixed flock behavior between the basic and evolved forms. Although flocking behavior (i.e., group of birds foraging or flying) is common for corvids and many other bird species, the specific case of mixed flocks of carrion crow and long-billed crow is infrequent despite their use of similar habitats and resources (Fujioka, 2020). Interestingly, the entry refers to these two Pokémon as nocturnal creatures (most likely because of their Dark Type association), as illicit activities are more likely to take place during nighttime, even when the active period of their real-world counterparts is daytime.

In the *Heart Gold/Soul Silver* editions (2009) the Pokédex refers to the unkindness of Honchkrow ("*It is merciless by nature. It is said that it never forgives the mistakes of its Murkrow followers*"), also alluding to the hierarchy ranks of these two Pokémon. This portrayal of crows as evil creatures – a shift from their historical veneration as wise and sacred creatures – could have its origins in the increase of crow populations in Japan and the damage they can cause to crop fields and livestock (Yoda, 2019). Moreover,

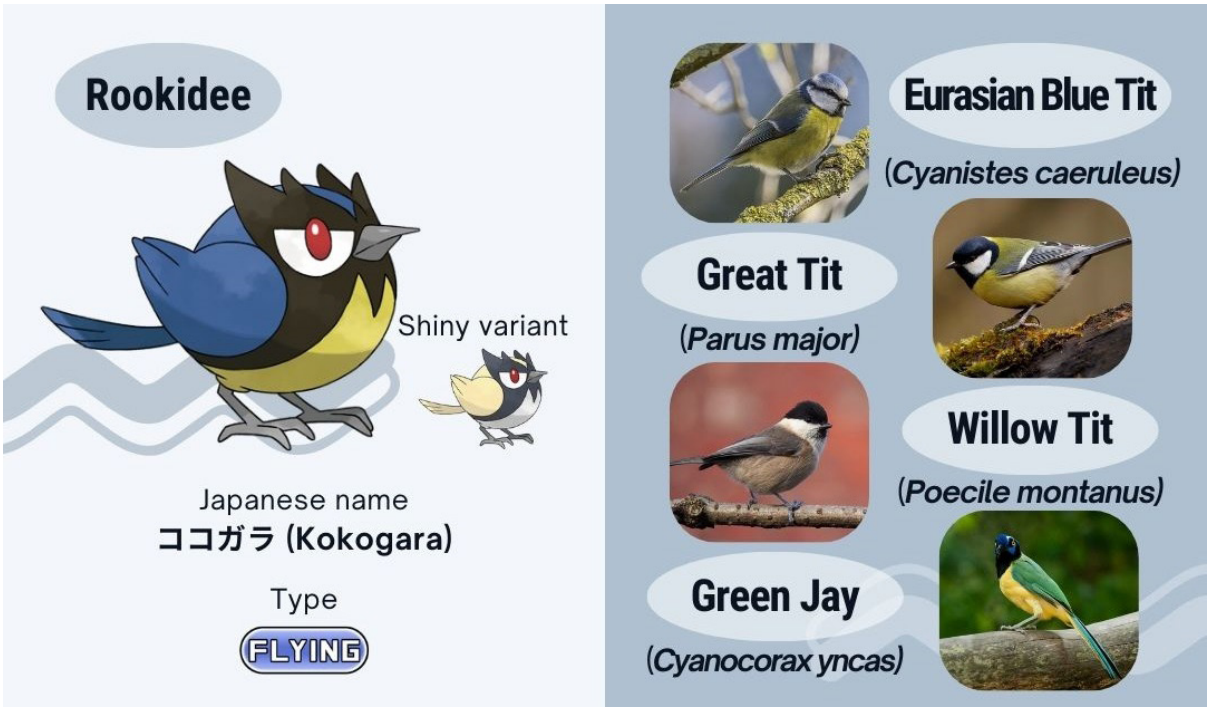

Figure 4. Official artwork of Rookidee and its shiny variant (©Nintendo/Game Freak, 1995–2023), introduced in Generation VIII. The right panel shows the hypothesized inspiration species, the Eurasian blue tit (C.J. Sharp; Wikimedia Commons, CC BY-SA 4.0); the great tit (F. Vassen, Wikimedia Commons, CC BY 2.0); the species similar to the shiny version and that shares the Japanese name, the willow tit (F.C. Franklin; Wikimedia Commons, CC BY-SA 3.0); and a corvid species with yellow plumage, the green jay (Dilankf; Wikimedia Commons, CC BY 3.0).

crows used to be considered a nuisance species in urban areas, due to a few records of crow aggression towards humans (Yoda, 2019).

Rookidee

This Pokémon appeared in the Sword/Shield (2019) games. The name is the combination of the words '**rookie**' (i.e., a person who is new to an organization or an activity; Cambridge Dictionary, 2023) and '**chickadee**', which refers to birds from the Paridae family, a group with no relation to crows (curiously, 'rook' is also the common name of another crow species: *Corvus frugilegus*). The Japanese name (ココガラ, Kokogara) results from the combination of the words '**ko**' (child or small) and '**kogara**', the Japanese common name for the willow tit (*Poecile montanus*), a name that makes note of the small size of the bird. The latter size reference could be a nod to Rookidee being the first form of the evolutionary line of Corviknight, thus the name also alludes to an untrained or novice page. The willow tit also resembles the shiny version of the Pokémon; although, according to Bulbapedia (2023), the shiny version is supposed to be inspired by the Japanese tit (*Parus minor*).

The appearance of Rookidee resembles a small bird (being in the category of "Tiny Bird Pokémon"). Its body has a fluffy, spherical aspect similar to that of chickadees and tits, but particularly to those of the Eurasian blue tit (*Cyanistes caeruleus*) and the great tit (*Parus major*). Rookidee shares a yellow, blue, and white coloration pattern of the Eurasian blue tit, albeit in different proportions, and the distinct black and white mask of the great tit (Fig. 4). Blue and black are also common colors for some corvid species (e.g., jays, magpies), while yellow is restricted to only a few corvid species (e.g., New World jays), like the Inca jay (*Cyanocorax yncas*).

A recent Pokédex entry from *Violet* (2022) reads: "*The females are fussier than the males. If another creature dirties a female Rookidee's*

Figure 5. Official artwork of Corvisquire (©Nintendo/Game Freak, 1995–2023) and its shiny variant, introduced in Generation VIII. The right panel shows the hypothesized inspiration species, the Steller's jay (J. St. John; Wikimedia Commons, CC BY 2.0); the hooded crow (A. Trepte; Wikimedia Commons, CC BY-SA 2.5); and the species similar to the shiny version, the Eurasian jay (L. Viatour; Wikimedia Commons, CC BY-SA 3.0).

wings, it'll peck the offender relentlessly in a burning rage". This and all other Pokédex entries for this Pokémon make reference to its bravery and aggressive behavior, a description highly accurate regarding some tit species, who become aggressive when competing for resources with other birds. Conversely, a study recorded willow tit males being the ones characterized by aggressive behavior towards other males, because a dominant behavior is a strategy to improve mate protection in an intraspecific setting (Lahti et al., 1996).

Corvisquire

The evolution of Rookidee was also introduced in the Sword/Shield (2019) game. The Pokémon name is composed of the words '**corvi**' as a reference to corvid or Corvidae (taxonomic family) and '**squire**', the name of the young nobleman that served and helped a knight as a part of their training to eventually become a knight (Merrian-Webster, 2023). Therefore, Corvisquire would be the intermediate part of the evolutionary line between Rookidee (i.e., a rookie page) and Corviknight (i.e., an experienced knight). The Japanese name for this Pokémon (アオガラス, Aogarasu) is the combination of the words '**ao**' (blue) and '**karasu**' (crow), an evident reference to the predominant feather color of jays and magpies. Both the shape and coloration pattern of the Corvisquire design resembles a Steller's jay (*Cyanocitta stelleri*) with a black head, blue body, and even retaining the characteristic black crest appreciated both in the Pokémon design and the real-world species (Fig. 5), although this is an American distributed species (BirdLife International, 2023). The hooded crow also shares a similar plumage pattern with Corvisquire. Likewise, the appearance of the shiny version (i.e., shades of beige and gray) is inspired by the strikingly similar Eurasian jay (*Garrulus glandarius*).

The Pokédex entries available for Corvisquire remark about the intelligence of this species (*Sword*: "*Smart enough to use tools in battle, these Pokémon have been seen picking up*

Figure 6. Official artwork of Corviknight (©Nintendo/Game Freak, 1995–2023), introduced in Generation VIII. The right panel shows the hypothesized inspiration species, the common raven (F. Losada Rodríguez; Wikimedia Commons, CC BY-SA 4.0).

rocks and flinging them or using ropes to wrap up enemies"). In an interesting review, Lefebvre and colleagues (2002) found repeated tool true-use (i.e., objects collected from the ground and held on the bill or foot to be used for different purposes) from many corvid species. The use of objects as weapons by birds is uncommon, but interestingly a Steller's jay individual was observed breaking a twig and using its sharp end as a weapon to attack an American crow (*Corvus brachyrhynchos*), in a display of aggressive behavior to access a food source (Balda, 2007). Although not mentioned in the entry, the use of tools as weapons could also be a reference to this Pokémon using a sword-like weapon, in a very similar way to the other swordsman Pokémon of this region, Sirfetch'd. In one of the most recent games, *Scarlet* (2022) the Pokédex entry reads: "*It's said that the reason behind Corvisquire's high level of intelligence is the large size of its brain relative to those of other bird Pokémon*". This description proves to be spot-on, as many studies report the complex uses of tools by corvids in correlation with brain size (Lefebvre et al., 2002; Emery, 2004), as it is pointed out by the Pokédex entry.

Corviknight

This Pokémon is the fully evolved form of its evolutionary line, and together with Rookidee and Corvisquire, it was also introduced in the Sword/Shield (2019) game. The name of Corviknight is a combination of the word '**corvi**' again as a general reference to corvids, but more specifically to the taxonomic genus that the common raven belongs to (i.e., *Corvus corax*) and '**knight**'. The official Japanese name is アーマーガア (Āmāgā) but it is also commonly romanized as 'Armorga'. The latter name is the amalgamation of the word '**armor**' and '**gā**' possibly representing an onomatopoeic sound similar to cawing or squawking.

Both languages' etymological origin perfectly reflects the morphological characteristics of Corviknight, as it resembles a common raven with its completely black coloration with a metallic dark blue sheen, broad bill, and robust body. Unlike its pre-

vious forms, Corviknight is a dual-type (i.e., Flying/Steel) with its design blending the metallic sheen of a raven's feathers into an armor-like structure (Fig. 6).

This Pokémon was introduced in Generation VIII, which takes place in the Galar region, based on the geography of the United Kingdom (Bulbapedia, 2023). This fact and the crown aspect of the head feathers of Corviknight have led to the belief that the Pokémon is based on the ravens protecting the Crown in the Tower of London. According to the legend, "*If the Tower of London ravens are lost or fly away, the Crown will fall and Britain with it*", thus a group of six common ravens is kept and tended at that location since the time of King Charles II (i.e., 1660–1685; Historic Royal Palaces, 2023).

The Pokédex entry of *Sword* reads as follows: "*This Pokémon reigns supreme in the skies of the Galar region. The black luster of its steel body could drive terror into the heart of any foe*". The way it refers to the imposing presence of Corviknight is contrastingly different from Murkrow and Honchkrow, where negative adjectives related to malice and bad omens are used. The last phrase of this entry could also be an allusion to medieval Black Knights (i.e., character trope that appears in literature, cinema, and other media), characterized by being mysterious, tragic, and overall feared by other characters or antagonists (Ashe, 2018). The shift in attitude towards these corvid Pokémon is also clear in the *Shield* Pokédex entry ("*With their great intellect and flying skills, these Pokémon very successfully act as the Galar region's airborne taxi service*"). It remarks on the outstanding intelligence of these birds – as with Corvisquire – but, additionally, it points out how people in this region recognize their ability as useful for serving society. This is a final reference to the evolutionary line of Corviknight being more appreciated than the misunderstood Honchkrow line.

CONCLUSION

Across the evolution of the *Pokémon* video game franchise, we can see how both the designs and lore behind Pokémon species have evolved too. At least in the case of the five reviewed corvid-inspired Pokémon, we can see how the use of adjectives in Generation II is negative and based on the superstitions and cultural prejudices that are also common for many other misunderstood animal species (Nagy & Johnson, 2013). It took 20 years (from the release of *Gold/Silver* in 1999 to the release of *Sword/Shield* in 2019) for the franchise to include other corvid-inspired Pokémon species, with developers deciding to provide a different perspective. Not only the graphic and other technological features were improved, but also the accuracy of the lore for these fictional creatures based on information available in the scientific literature about the fascinating ecology and behavior of their real-life corvid counterparts. Either a coincidence or deliberate research work from developers, the information reviewed for this article is an excellent example of how Pokémon is not only one of the most successful media franchises in the world but also an exceptional and fun way to learn about wildlife, natural sciences, and cultural references from many places. Ultimately, we highlight the potential of the *Pokémon* world as a tool to engage with people – particularly children –, spark an interest in natural sciences careers, and replace outdated beliefs with new evidence-based arguments in favor of nature conservation.

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Dr. **Miguel A. Gómez-Martínez** is a doctor by profession, but a geek at heart. His research is mainly focused on avian urban ecology. However, he is also interested in a broad variety of subjects such as avian behavior, bird migration, insular bird ecology, conservation, ethnobiology, and science dissemination. He is also a big fan of video games (mainly JRPGs) and anime. Specifically, one of the first games he played was the *Pokémon Blue* version and he is convinced that it was one of the reasons to choose biology as a career.

Michelle García-Arroyo, MSc., is a Ph.D. student in wildlife biology, with her research focused on avian urban ecology. She is fascinated by the feathered creatures' quirky behaviors and enjoys delving into the history and reasoning behind the widespread pop culture and internet presence of these lovely *birbs*. She firmly believes that the study of human-wildlife interactions from the cultural perspective is a fundamental axis for biodiversity conservation in an increasingly urbanized world.

Journal of Geek Studies

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The Batman and the Great Depression: the birth of an ordinary hero

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"Why do we fall, Bruce? So that we can learn to pick ourselves up."

Batman Begins (Warner Bros., 2005)

Batman's first appearance: Detective Comics #27 (source: Batman Fandom).

A multimillionaire playboy who disguises himself as a bat to beat Gotham's underworld to a pulp by night: at first glance, the Batman is nothing more than an eccentric, neurotic superhero with a penchant for latex. Yet the story of his birth reminds us of one of the darkest chapters in American history.

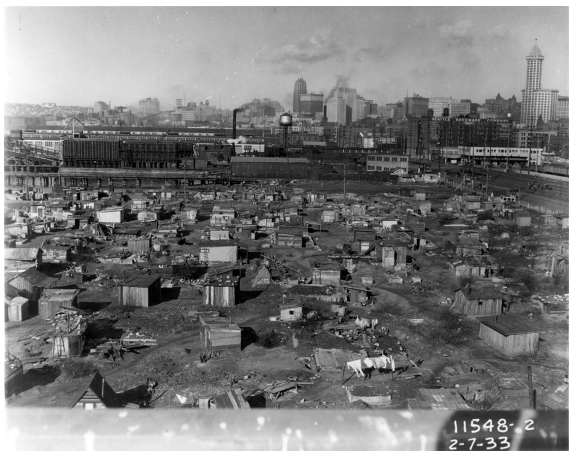
The date is October 24, 1929, a day that would go down in history as 'Black Thursday'. With 9 billion dollars going up in smoke in the space of one hour and a half, the resounding crash of the Wall Street stock market precipitated the ruin of numerous small shareholders. Overnight, thousands of households found themselves penniless. "*When Wall Street took that tail spin, you had to stand in line to get a window to jump out of, and speculators were selling spaces for bodies in the East River,*" a satirical New York newspaper reported. It was widely believed that bankers and ruined investors had climbed to the top of Manhattan's skyscrapers, ready for the great plunge that mimicked the American economy's... But actually, the only figure haunting the rooftops of New York at that time, preparing for his sensational entrance, was wearing a black mask with pointed ears.

Black Thursday was just the beginning. The crisis soon seeped through the rest of the planet like a poison. The United States were hit by the Great Depression, which would only end in 1933 following the revival efforts of President Franklin D. Roosevelt. Despite the hesitant economy recovery (a quarter of the population was still unemployed), the country did not regain the optimism that had electrified it a few years earlier. For the majority of the American population, an alternative to the prevailing doldrums was to be found in the entertainment industry. Here, too, the damage was serious: Hollywood was almost broke, the major studios had collapsed, the national baseball league had had to get rid of fourteen teams for lack of sufficient funds... But the country pulled itself together by playing *Monopoly*, introduced in 1935 (fictitious

bankruptcy was still better than real ruin), swing dancing in cafés and listening to radio soap operas. In cinemas, musicals and comedies triumphed, led by the audacity of the Marx Brothers, and *The Wizard of Oz* dazzled audiences in Technicolor. Less pastel-coloured but just as popular, the gangster made his entrance on the screens as a familiar figure, cousin of the underprivileged – some sort of Robin Hood with a porkpie hat and a machine gun...

All in all, the fears and hopes of the time were inevitably reflected in the entertainment industry. Comic books were no exception.

Bat-Man – as he was known in his early days – was a child of these times of misery. He appeared in March 1939 (Detective Comics #27) in a wound opened wide by the Great Depression that was still festering: a character tormented by his past, bitter and violent, whose distress was not material but moral. Orphaned at the age of ten, he matured too quickly amid the brambles of a scarred childhood; he became a bitter, solitary adult, fading into the shadows of his hometown. His favourite hunting ground, like the bats he has made his emblem, is the Gotham nightlife, especially its winding alleys teeming with murders and trafficking of all kinds. The very structure of the fictional city reflects an unhappy, disaster-stricken era, a sort of evil double of the sprawling megacities that were beginning to mushroom across America, with their strips of reinforced concrete stretching as far as the eye can see. In the centre of Gotham, the disreputable Narrows district, bristling with shanty towns, is reminiscent of the makeshift architecture of 'Hooverville', a tin district built by the dispossessed during the Great Depression, and named after the president of the time, Herbert Hoover. The parallel with the Big Apple, the city hardest hit by the crisis, is obvious: Gotham has been its unofficial nickname since 1807. The name was borrowed from an eponymous town in Nottinghamshire, England, which was the scene of a semi-legendary incident in the early 13th century: in order to spare themselves a visit from King John, its inhabitants were said to have feigned madness... It was enough to inspire the creators of the Batman, who imagined a metropolis on the brink of chaos. "*We didn't call it New York because we wanted everyone, whatever their city, to identify with it*," the magazine's scriptwriter, Bill Finger, admitted. And it worked: in people's minds, Gotham became a refuge for the unfortunate, a hornet's nest where everyone could project their terrors and frustrations.

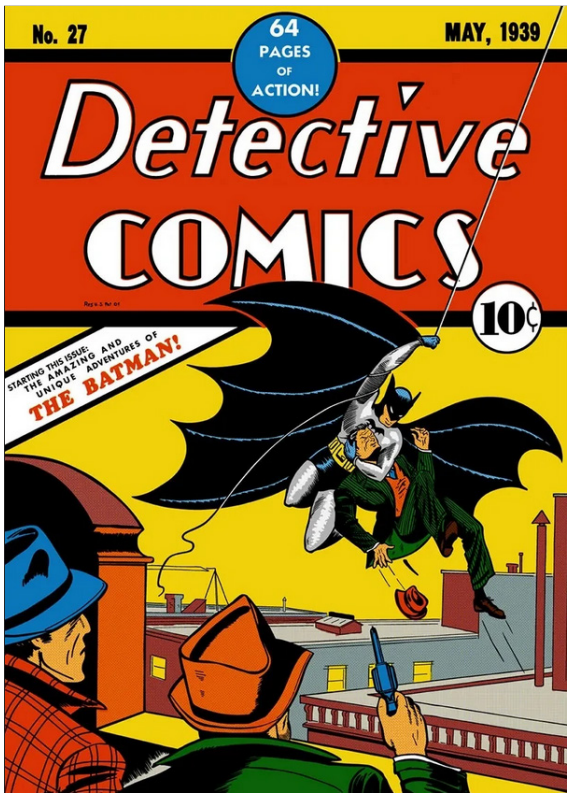


Hooverville on the Seattle tide flats, Seattle, Washington, USA, 1933 (source: Seattle Municipal Archives via Wikimedia Commons, CC BY 2.0).

Keep in mind that the Batman was not the first-born of this universe: a year earlier, Superman had made a cataclysmic arrival on American newsstands. Inserted carelessly between the pages of Action Comics #1 – today considered the most valuable comic book in the genre – he was immediately embraced by his readership. The story of an extraterrestrial performing miracles in the service of planet Earth reached the heart of many a morose American: in order to build on this success, his publishers launched the Batman into the breach a few months later. But the differences between the two works are pretty clear. While Superman, his alter-ego of light, protects the weak and defenceless with his X-ray vision and overdeveloped hearing, the Batman plunges into the night armed only with his thirst for vengeance. Incidentally, in the first issue where the dark knight is featured, he ruthlessly throws a criminal into a vat of acid.

Here's another interesting point of di-

vergence between the two works: Superman is an extraterrestrial, a product of the science-fiction repertoire with biblical overtones (his baptismal name, Kal-El, means 'the voice of God' in Hebrew). Less colourful, the Batman is a film noir detective, modelled on the short stories of Poe or Conan Doyle, who shares, through his original trauma, the suffering of millions of Americans. Unsurprisingly, the original inspiration for Batman came from Zorro, the archetypal outlaw acclaimed by the masses, and owes a great deal to Douglas Fairbanks' performance in *The Mark of Zorro* (United Artists, 1920). In his early days, the Batman was blond and borrowed his red tights from his colleague Superman... After spotting a sketch of the flying machine imagined by Leonardo da Vinci in the 15th century, scriptwriter Bill Finger gave him a bit of sobriety by dressing him up as a bat.



Bob Kane's original design for the Batman, ca. 1939 (source: Reddit).

Despite their differences, both characters represent the culmination of the American dream. They were imagined by immigrants or descendants of immigrants: it is no coincidence that their heroes transcend the difficulties of their past – the destruction of Krypton for one, the murder of his parents for the other – and distance themselves from their roots to fight their own battles. In doing so, they mimic the mindset of many Americans left behind by the Great Depression. The dual identities of Bruce Wayne/Batman and Clark Kent/Superman make this sublimation possible: considered ordinary individuals in civilian life, they become extraordinary characters under the anonymity of the cape. This elevation looks like a challenge addressed to all the working classes convalescent from the 1929 crisis.

The Batman's ideal of vigilantism, even more than that of his tights-wearing counterpart, reflected the peak of crime registered in American megacities throughout the Prohibition. In the 1920s, the ban on the sale of alcohol boosted smuggling and trafficking: big shots like Al Capone, John Dillinger, Machine Gun Kelly, Clyde Barrow, and Bonnie Parker became famous through these troubled times, often regarded with indulgence and even affection by the public. The Batman disagreed: "*Criminals are a superstitious cowardly lot, so my disguise must be able to strike terror into their hearts. I must be a creature of the night, black, terrible.*" He thus decided to cut the evil at the root by untying the criminal knots that strangled the city. In this, he is reminiscent of the police crusade undertaken by President Roosevelt, who gave full powers to the FBI in the early 1930s to lock up the underworld of New York, Chicago and elsewhere. The five crime lords mentioned above were all imprisoned or eliminated before 1935, and both the general public and the cinema started to glorify the 'G-Men', government agents led with an iron fist by John Edgar Hoover, FBI's director (who, incidentally, made several appearances alongside the good guys in the comic universe, sharing a cover with the Batman in January 1942). Through the caped crusader, the country reconciled itself with its authorities and cherished the hope of a new-found civil peace… Even though the world was heading for war.

Like the Bat-Signal piercing the darkness of Gotham, the character of the Batman is a beam of light cutting the night of the Great Depression. It is – and remains – the popular expression of a hope that comes from the gutter and never dies, whispering to the masses: sleep tight, everything will be better tomorrow. The Black Knight keeps watch.

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About the author

After working some time in business and communication, Nicolas Méra quit everything to follow his sheer passion for science popularization. Learning the ropes of historical investigation at a local preventive archaeology department in Chartres, France, he now writes history books and publishes pop science articles for various print and online magazines. Which is why, he thinks, he's been sent to Earth in the first place.

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The magic of transformation: a comparative analysis of alchemy in *Harry Potter* and its real-world chemistry roots

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"I've never wanted to be a witch, but an alchemist, now that's a different matter. To invent this wizard world, I've learned a ridiculous amount about alchemy. Perhaps much of it I'll never use in the books, but I have to know in detail what magic can and cannot do in order to set the parameters and establish the stories' internal logic."

J. K. Rowling

Alchemy is an ancient practice that combines multiple fields of study including philosophy, mysticism, and chemistry. It is largely concerned with the transformation of matter, particularly the transformation of base metals into more valuable metals like gold or silver. Alchemists also sought to create elixirs or potions that could bring about immortality or cure diseases. The origins of alchemy date back to Ancient Egypt and Greece, with early practitioners believing that by unlocking the secrets of the universe's workings, they could attain greater knowledge and power. Over time, alchemy evolved with the influences of various cultures and philosophies, becoming a complex blend of spiritual and scientific practices. While alchemists were unsuccessful in their attempts to transmute metals or create elixirs, their practices paved the way for modern chemistry and scientific inquiry. Today, alchemy is still studied as a historical and spiritual practice, but it is no longer considered a legitimate scientific pursuit. (Principe, 2012; Read, 2012)

HISTORY OF ALCHEMY

Alchemy combines the philosophical view and concrete practical method with the goal of conquering absolute Wisdom and Immortality. Alchemists aimed at personal improvement and creation of various materials with unusual properties. The alchemists' practical method evolved into the basis of modern chemistry as they created techniques for analyzing, identifying and separating substances. Also, many glassware still used in chemical laboratories today were the creations of alchemists. (Newman, 2006; Read, 2012)

Alchemy developed both in the Western world and in the East or Far East. The main difference between the ways alchemy developed was the fact that in the West, the main goal of alchemy was to transform common metals into gold, while in the Far East, the main goal was to discover substances and medicines for the common good (Szydło, 2022). The first traces of Western alchemy can be found in Ancient Egypt (Nummedal, 2012; Read, 2012). Then, alchemical knowledge was passed on to the Ancient Greeks and then to the Arabs. By the time of the Arabs, alchemy was a mixture of philosophical considerations, allegories, symbols and

coded languages. During the Arab period (i.e., the 8th century CE), alchemy began to become a recognizable practice.

In the Ancient Egyptian world, alchemy was closely tied to the practice of embalming the dead, as well as the pursuit of knowledge related to metallurgy and glass-making. The practice of alchemy spread throughout the Middle East and into Persia, where Islamic scholars translated Greek and Persian texts related to alchemy and added their own insights. During the Middle Ages in Europe, alchemy continued to evolve and became closely tied to spiritual and religious beliefs. It was believed that alchemists sought not only to transmute base metals into gold but also to achieve spiritual transcendence and immortality. Alchemical texts from this period often included descriptions of mythical creatures, astrological signs, and debates about the nature of the soul and the universe. The Renaissance saw a resurgence of interest in alchemy as a scientific pursuit, with figures like Leonardo Da Vinci and Isaac Newton engaging in the study of alchemical principles. During this time, alchemy was recognized as an important precursor to modern chemistry, with its focus on experimentation and observation. Despite its influence on modern science, alchemy gradually lost much of its scientific credibility during the Enlightenment and the rise of modern chemistry. Today, the practice of alchemy remains a fascinating reminder of ancient scientific and philosophical pursuits and continues to inspire modern thinkers who seek to understand the mysteries of the natural world. (Read, 2012; Losure, 2017; Calian, 2010; Figala, 2004)

ALCHEMY & CHEMISTRY

Alchemy and chemistry are two different fields of study, although they share some similarities. Alchemy was a philosophical and proto-scientific tradition that developed in the ancient world and continued through the medieval period up until the 17th century, while chemistry is a scientific discipline that emerged in the late 18th cen-

Figure 1. *Alchemist Heating a Pot*, by David Teniers the Younger (1610–1690), oil on canvas (public domain).

tury. The main difference between alchemy and chemistry is in their goals and methods. Alchemy was primarily concerned with transforming matter and achieving spiritual transformation, while chemistry focuses on understanding the properties, composition, and behavior of matter. Alchemists worked with mysterious substances like the Philosopher's Stone and elixirs of immortality, often using symbolism and mysticism to explain their work. In contrast, chemists aim to observe and explain the physical phenomena they study, using quantitative data and experimental evidence to support their theories. Another difference between alchemy and chemistry is the level of rigor in their methods. Alchemists generally did not have access to the level of instrumentation and quantitative measurement that chemists have today, leading to less rigorous experimentation and greater reliance on intuition and anecdotal evidence. By contrast, modern chemistry relies extensively on precise measurements and experimental data. (Greenberg, 2007; Moran, 2005)

Despite these differences, there are some similarities between alchemy and chemistry. Both fields involve working with matter and creating new substances, and both have contributed to our understanding of the world around us. Additionally, some of the terminology and symbolism of alchemy has been carried over into modern chemistry, such as the use of symbols to represent elements and the idea of transmutation. Additionally, the development of chemistry owes a great deal to the work of alchemists, who developed many of the laboratory techniques and procedures that are still used today. (Abbri, 2000; Read, 2012)

MODERN ALCHEMISTS

Researchers from University of Michigan state that some bacteria act as modern alchemists to turn a toxic liquid into gold. The groundbreaking study, which the researchers themselves refer to as "Microbial Alchemy", is based on a type of bacteria with the scientific name *Cupriavidus metallidurans*. These bacteria have the ability to be particularly resistant to heavy, toxic metals, up to 25 times stronger than common bacteria. However, what is even more fascinating is that these particular bacteria, according to the researchers, have the unexpected property of transforming gold chloride (a toxic liquid found in nature) into gold. The process of converting the liquid chloride into gold takes approximately one week, during which the bacteria reproduce. In the end, the chloride is transformed into solid 24-karat gold. (Reith et al., 2006; Brown & Kashefi, 2012).

ALCHEMY IN *HARRY POTTER*

Alchemy has been a significant part of the *Harry Potter* series (J.K. Rowling, 1997, 1998, 1999, 2000, 2003, 2005, 2007) since its inception. From Nicholas Flamel's creation of the Philosopher's Stone to the elusive Elixir of Life, the concept of alchemy has been woven into the narrative. In the Harry Potter universe, alchemy is a branch of magic that involves the transmutation of matter and the manipulation of the elements to create potions and elixirs that can achieve various effects. This has allowed alchemy to be an essential feature of both the plot and the magic system of the *Harry Potter* series.

Philosopher's Stone: The Philosopher's Stone is a central element in alchemy and is a key plot point in the first *Harry Potter* book. The stone is said to have the power to turn any metal into gold and create the Elixir of Life.

Horcruxes: The creation of Horcruxes is a dark and twisted form of alchemy in which the soul is split in order to achieve immortality. Voldemort uses this procedure to create seven Horcruxes, each containing a piece of his soul, making him nearly impossible to kill.

Polyjuice Potion: The Polyjuice Potion is an example of alchemy used for transformative purposes. The potion allows the drinker to assume the appearance of another person, but requires a variety of ingredients and some advanced knowledge of alchemy to create.

Figure 2. The potions classroom. Screen capture from *Harry Potter and the Philosopher's Stone* (Warner Bros. Pictures, 2001).

Mandrake Restorative Draught: The Mandrake Restorative Draught is an alchemical potion that is used to revive petrified individuals. The potion requires the use of mature Mandrake roots, which are extremely dangerous to handle and require special knowledge of alchemical procedures.

Nicholas Flamel: One of the most significant references to alchemy in the *Harry Potter* series is Nicholas Flamel, a real-life alchemist who is also a character in J.K. Rowling's books. In the novels, Flamel is famous for creating the Philosopher's Stone, a substance that can turn any metal into gold and produce the Elixir of Life that grants immortality to those who consume it. This concept is central to the first book, "Harry Potter and the Philosopher's Stone" where the villainous Voldemort seeks the Stone to regain his form and wreak havoc on the world.

Draco Malfoy: According to J.K. Rowling, Draco Malfoy, after the Battle of Hogwarts, was fascinated by alchemical manuscripts. His obsession with alchemy was pure as he wished to use it to become a better man.

In addition to the examples mentioned above, there are several other instances of alchemy in the Harry Potter series.

The symbolism of the colors red, white, and black, which are traditionally associated with alchemy. These colors are significant in the series, particularly in reference to the philosopher's stone and the colors of the Hogwarts houses.

The role of the Hogwarts founders, who are associated with aspects of alchemical symbolism. Godric Gryffindor is associated with fire, Rowena Ravenclaw with air, Helga Hufflepuff with earth, and Salazar Slytherin with the element of water, which is often connected to emotions and intuition in alchemical lore.

Furthermore, the use of magical creatures, such as phoenixes, dragons, and unicorns, which have long been associated with alchemical symbolism. These creatures represent transformation, regeneration, and spiritual purity.

Figure 3. The Founders of Hogwarts with their Elements.

Another interesting example of alchemy in the *Harry Potter* series is the use of the

Deathly Hallows. The three hallows – the Elder Wand, the Resurrection Stone, and the Invisibility Cloak – represent a powerful tool for those seeking mastery over death. This theme is similar to the alchemical concept of transmutation, which was ultimately aimed at achieving immortality. Additionally, the idea of the Invisibility Cloak reflects the alchemical concept of the mystical veil, which acted as a barrier between the physical and the spiritual worlds. The veil was often described in alchemical texts as a symbol of the division between life and death, and the Invisibility Cloak in the *Harry Potter* series similarly represents a way to move between these two realms. The symbolism of the Deathly Hallows also incorporates the themes of duality and balance, which are central to alchemical philosophy. The Elder Wand represents power and domination, while the Resurrection Stone represents life and the afterlife, and the Invisibility Cloak represents secrecy and protection. Together, the three hallows symbolize the balance of opposing forces in alchemical philosophy.

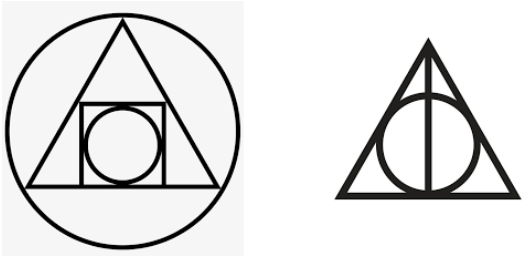

Figure 4. Left: the symbol of the Philosopher's stone. Right: The Deathly Hallows symbol.

Another critical aspect of alchemy in the *Harry Potter* series is its link to the idea of transformation and self-improvement. In alchemical lore, the process of transmuting matter is thought to be an analogy for spiritual transformation. The *Harry Potter* books explore this concept in several ways, most notably through the character of Severus Snape, who is a presumed alchemist as well as a complex and flawed individual. Snape's story is one of redemption and growth, as he transforms from a bitter and resentful person into a hero willing to sacrifice himself for the greater good.

DISCUSSION

Alchemy is a critical element of the *Harry Potter* series and adds a layer of complexity and depth to the fictional world. From the creation of the Philosopher's Stone to the theme of transformation and growth, alchemy is a powerful force in the magical universe crafted by J.K. Rowling. Its use in the series demonstrates how fantasy can draw on real-world mythos and traditions to create a captivating and fully realized narrative.

Chemistry can be regarded as the scientific discipline intertwined with alchemy. Chemistry also plays a significant role in the *Harry Potter* series, particularly in the creation of potions. Potions are a fundamental aspect of magic, and they are used for a wide range of purposes, from healing to transforming objects and animals. Potions require precise measurement, careful mixing, and specific preparations, much like chemistry does. Throughout the series, various characters create and use potions to accomplish their goals. Correctly brewing a potion requires an understanding of the properties of different substances, chemical reactions, and changes in states of matter, all of which fall under the realm of chemistry.

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What Lasts of Us: implicit archaeology through environmental storytelling

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In the seminal work "Hamlet on the Holodeck" (1997), Janet Murray lists "spatial" as one of four basic characteristics of the new forms of digital storytelling, including (but not limited to) video games (pp. 96–100). Digital environments, Murray explains, are not only capable of representing space (as a literary text or a film), but also of opening that space up to user navigation or exploration (p. 96). Over the years, video game spaces have evolved from interactive digital spaces represented or evoked through words on a screen (e.g., the famous 1980s text adventures by Infocom), to meticulously detailed 3D environments able to house thousands of players simultaneously, or immersive virtual reality environments where players can use their own bodies to physically traverse the game space.

Video game spaces have, in recent years, attracted the attention of archaeologists who use archaeological methods to study these digital environments. Pioneering this approach is Andrew Reinhard, who in 2018 published the book "Archaeogaming: An Introduction to Archaeology in and of Video Games" which outlined how archaeological methods of analysis may be applied to video games. The term 'archaeogaming' itself is older and dates back to Reinhard's blog, launched in 2013 (Rassalle, 2021: p. 4). Archaeogaming, Reinhard explains (2018: p. 3), comprises various fields of study, including:

(1) "the study of physical video games as well as the metadata surrounding the games";

(2) "the study of archaeology within video games"';

(3) "the application of archaeological methods to synthetic space";

(4) "the approach to understanding how game design manifests everything players see and interact with in-world"; and, finally,

(5) the "archaeology of game mechanics and the entanglement of code with players".

Examples of archaeogaming scholarship include, for example, analyses of the representation of history and epigraphy in *Heaven's Vault* (Inkle, 2019) (Hageneuer, 2021); investigations of player-created cities in *Star Wars Galaxies* (Sony Online Entertainment, 2003–2011) (Hansen, 2020); inquiries into the consultation of archaeologists or historians during game development (e.g., Poiron, 2021 on *Assassin's Creed Origins' Discovery Tour*; Ubisoft Montreal, 2018); or the study of virtual recreations of history constructed by scholars entirely (e.g., Holter et al., 2020). Archaeogaming may also refer to the archaeology **of** video games, as exemplified by the 2014 excavation of the Atari burial site in Alamogordo, New Mexico (Reinhard, 2018). The term 'archaeogaming' has rapidly expanded and has become the subject of its own yearly conference ('Ar-

chaeogaming Con', organized online by the Archaeogaming Collective).

This chapter applies methods of archaeogaming for the analysis of how the mechanics and dynamics of *The Last of Us* allows (or requires) the player to adopt an 'archaeological mindset' during the act of play. We argue that the featured in-game exploration and methods of world-building ask that the player performs acts of implicit archaeology, as they reconstruct the game world's history based on the material evidence they encounter. The next sections overview the use of environmental storytelling in gaming, what the archaeological mindset is, the setting and story presented within *The Last of Us*, and how the game invites the player to conduct implicit archaeology.

ENVIRONMENTAL STORYTELLING IN GAMING

Associated with the concept of video game space is the notion of environmental storytelling. Originally coined in the context of theme park storytelling (Carson, 2000), the term was later used and popularized by Henry Jenkins (2004) to describe video game environments as a form of "narrative architecture". In order to tell a story, video game designers are often not only required to devise intricate narrative plots or create compelling characters, but they also need to create a virtual world and carefully disperse the narrative story beats throughout that world. This requires setting a world or stage that is recognizable to the story's needs. Items, backgrounds, architectures, and more are presented to the player to assist in building the narrative.

Video game methods of storytelling have been linked to archaeology in the past. Fernández-Vara (2020) has for example shown how her concept of "indexical storytelling" (Fernández-Vara, 2011) – i.e., storytelling driven by objects that serve as evocative 'indices' (in the Peircean sense) of certain backstories – relates to archaeology, since archaeology also relies on material objects in order to inform and tell a (hi) story. According to Fernández-Vara (2020), this then leads to "exegetic gameplay", or gameplay "where the game goal is to interpret information" and to "fill informational / conceptual gaps". Game designers, she argues, are forced to ponder questions such as "What happened in the environment? How has it left a trace in the space? How can the player read those traces to reconstruct the events?" (ibid.). Subsequently, they implement objects in the game space that both evoke and answer these questions. Our chapter builds on these insights, but instead of looking at the architecture of game design, we explore player discovery and cognition. Our focus lies with the mental process of the player, as it is up to them to reconstruct a history or to form hypotheses about the game world's past through interactive discovery of the game world.

THE ARCHAEOLOGICAL MINDSET

Archaeology, in a most basic definition, seeks to understand the past by analyzing artifacts and ecofacts, termed material culture, left behind by cultural groups. Architecture, items, tools, cultural landscapes – these are all **things** that have been constructed, molded, or used by humans. Archaeologists examine materials and landscapes to reconstruct the lived experiences of the past. However, popular culture has significantly warped the public's perceptions of what the modern archaeological research process looks like. Many interpretations in popular culture reflect an antiquarian notion of plundering the past, as may be observed in the exploits of Indiana Jones or Lara Croft. To break down the archaeological mindset constructed by *The Last of Us*, we must first present a brief overview of the discipline itself.

Archaeology as we know it was only codified in the first half of the 20th century. Before that, the discipline consisted of an assortment of art history enthusiasts, literature scholars, historians, and most commonly adventurers and treasure hunters

(often from European countries) traveling to sites that were rich in archaeological remains to obtain precious artifacts. The goal of these first expeditions was not to record and try to understand the past, but the discovery and acquisition, often through destructive means, of objects of value that could then be sold to collections and antiquarians (Trigger, 2006). Between the middle of the 19th and the first half of the 20th century, the focus of the research shifted from finding precious things to recording and understanding sites and material culture (Renfrew & Bahn, 2020; Trigger, 2006).

Much of the public is familiar with the fieldwork of archaeology, the digging and excavation and procurement of artifacts. In reality, there are many steps prior to excavation and after. Prior to an excavation, archaeologists research regional histories, cultures, and material cultures. In academic archaeology, often the researchers specialize in the context of their excavations. In commercial archaeology, archaeologists are given time to conduct background research of a project area prior to fieldwork. During excavations, archaeologists in essence treat the project like a crime scene. Each step of the process comes with careful notation, mapping, photographing, and more. As archaeologists cannot redo an excavation, it is imperative they record as much of their actions and findings as possible. Following excavations, researchers must curate the materials collected for posterity. All of their notes, photographs, maps, and artifacts are analyzed and preserved so that anyone in the future can return to these collections for further study. This summary is severely over-generalized, but much of the public is only aware of a small percentage of the specialized research and labor required.

In an ideal world, the goal of any archaeological mission would be to excavate and document sites in their entirety (Renfrew & Bahn, 2020). This means analyzing all the finds in their context, cataloging them, and giving them to the appropriate institutions for display or further research. The final step would be the publication of a complete report explaining the history of the site and of the people who occupied it as inferred from the objects and features discovered during the excavation process. If there are buildings, they would also need to be preserved or restored. In the real world, archaeologists attempt to do all of the above while working against deadlines, natural or man-made destruction (and sometimes looting) of sites, and the generally fragmentary nature of the archaeological record. Regretfully, these factors affect the scholars' ability to reach definitive conclusions on many open questions. On the other hand, the fact that new discoveries can quite literally rewrite history is one of the most thrilling features of archaeology as a discipline: the field never stops moving forward, the more we look backward.

In video games featuring one or more characters defined as 'archaeologists' (for instance the *Tomb Raider* and *Indiana Jones* series, to name the most popular titles), their behavior very often resembles more closely that of treasure hunters than that of modern-day professional archeologists. Although the main motive for undertaking an expedition may be a genuine desire to understand the past, or at least a particular past event, the methods employed (including sometimes using explosives to access ancient sites) are usually reduced to a very linear sequence of actions:

Character	Motivation(s)	Method	Outcome
Archaeologist	Understanding the past / past event	Reach site	Take thing(s)
	Prevent looting	Access building / container	OR
		Find thing(s)	Leave things in situ
Treasure hunter	Finding precious objects to loot	Reach site	Take thing(s)
		Access building / container	
		Find thing(s)	

What is most often absent from this hyper-simplified representation of archaeology is the recording. Sites can be a backdrop for the material culture, rather than the proper context in which the objects and the people who used them need to be investigated. Characters may comment on the architecture, but it is rare to see anyone recording the sites and the position of the artifacts before removing them. Chronology can be just as absent, as buildings are often regarded as 'frozen in time' (as in, built on a specific date and never modified) rather than as having had various phases of life and abandonment in which parts could be added, removed, or used for different purposes than the original ones.

Most importantly, and in stark contrast with both real-life archaeology and the gameplay of *The Last of Us*, knowledge of the past is very often too clear and immediately understandable from a cursory run through a single site. On the other hand, the discipline of archaeology is a constant dialectical opposition between wanting to understand the lived experiences of the past and being presented with data that are unclear, fragmentary, and in extreme cases outright absent. The confusion and frustration of the characters (and, by extension, players) in the world of the *The Last of Us* in trying to make sense of past events that, albeit recent, are poorly documented and must be painstakingly reconstructed through fragmentary material culture, are a surprisingly accurate analogy for how archaeological research is conducted in the real world.

THE LAST OF US

The Last of Us and its 2020 sequel represent a dystopian, post-apocalyptic setting of the United States. In 2013, a contagious fungus-based plague, known in the lore as the 'Cordyceps brain infection', breaks out and dramatically changes the world: humans affected turn into zombie-like 'Infected', and the surviving humans group themselves in ideological factions that are at war with each other, such as the Fireflies or the Washington Liberation Front ('Wolves'). The first game, set in 2033, tells the story of Joel and Ellie. Rumored to be immune to the disease, Ellie is smuggled across the country to a Firefly facility by Joel in an attempt to manufacture a cure. The game follows the growth of the relationship between Joel and Ellie as they travel across various locations and encounter extreme dangers. Over this time, Joel grows fond of Ellie, and their connection effectively becomes a father-daughter relationship. At the end of the game, Joel finds out that Ellie would not survive the procedure, and has to choose between humanity's salvation from the Cordyceps contagion or Ellie. Joel storms the hospital where the procedure occurs, murdering Firefly soldiers, nurses, and surgeons. While he rescues Ellie from certain death, he also dooms society to the pandemic. The sequel, set five years later, revolves around a more mature Ellie and her quest for revenge when Joel is brutally killed in front of her by Abby, the daughter of one of the doctors that Joel killed at the end of *Part 1*. Players control both Ellie and Abby and learn the justifications of both characters. At the end of *Part 2*, Ellie lets Abby go as she realizes her desire for revenge would only consume her more and will not change what happened.

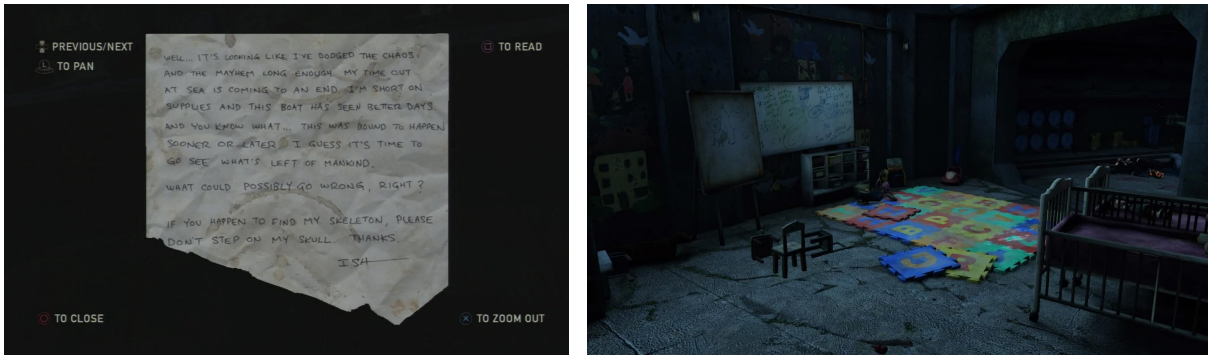
It is assumed that the 21st century events prior to the Cordyceps plague in *The Last of Us* follow real world events up to 2013, with the brain infecting disease as the catalyst for the post-apocalyptic environment seen in the series. As such, the world should be very familiar to players who have visited or lived in locations presented in the games. The two games take place across a variety of American cities, including Boston, Pittsburgh, Jackson, Salt Lake City, Seattle, Santa Barbara and others. In the games, all of the cities are presented as modern-day ruins: players journey through abandoned homes, hospitals, hotels, schools, coffee shops, and more. The game very frequently includes locations where people used to come together, or places that emphasized the very act of living. In the current situation, however, these places have become tombs for the ways of the past and are all marked by

the absence of life and the people that visited them. Yet these locations do contain evidence of life: many spaces are frozen in time, as it were, and remain relatively untouched after they were abandoned during the outbreak. There are letters and notes that contain and tell the stories of the people who inhabited the world. As we will now go on to show, it is primarily these (collectible) sources of life and history that allow us to engage in a form of 'implicit' archaeology while playing the game.

IMPLICIT ARCHAEOLOGY IN *THE LAST OF US*

Game developers meticulously build maps, settings, and items to establish a landscape for the players. In this sense, every item serves a purpose in setting the stage. As such, playing through an implicit archaeological lens means you are attempting to discern the (history of the) crafted world and characters' intent as created by the developers. Within *The Last of Us*, this comes two-fold. As mentioned previously, developers mimicked a real-world backdrop, which meant recreating regional architecture, environment, and potentially culturally accurate items. In a second form, the players (as Joel) can pick up items, which the game even terms as 'artifacts' that provide context and background for the events that have unfolded since 2013. Artifacts include notes, signage, keys, maps, diaries, and more. In some cases, these items clue the player in to where to go next, but the artifacts can also simply provide small vignettes into the lived experiences of people during the last twenty years.

We argue that players often inherently adopt the previously described archaeological mindset or practices within the setting of *The Last of Us* to progress through the story, or during their explorations of the game world. In this section we provide a case study to examine how artifacts within the game provide players with a historical and archaeological 'excavation' and interpretation based on the environmental storytelling and artifacts presented in the chapter. At one point in *Part 1*, the group travels through a Pittsburgh suburb and to a sewer encampment. As they proceed through the sewers, Joel encounters notes, maps, and letters that allow him to learn about the people who previously lived in the sewer safehouse. Most of these notes are signed by an individual named Ish. Through these artifacts and examining the sewers, Joel (and the player) learns that after the outbreak Ish took up residence with a small group of other survivors. The sewers became a somewhat thriving community that even included a school for several children. The children often painted on the walls and doors of the sewers, which is still evident as players walk through the level. Unfortunately, one day a door was left open and a horde of infected stormed the sewers. Ish's fate is left unknown, his existence only known to Joel and the player through the artifacts left behind. The game developers set the environment up in such a way that players learn the story of Ish in a somewhat chronological manner, rather than through haphazard scattered fragments. As players progress through the levels, they uncover the next



One of Ish's notes and the makeshift school (*The Last of Us Part 1*, screen capture from the game).

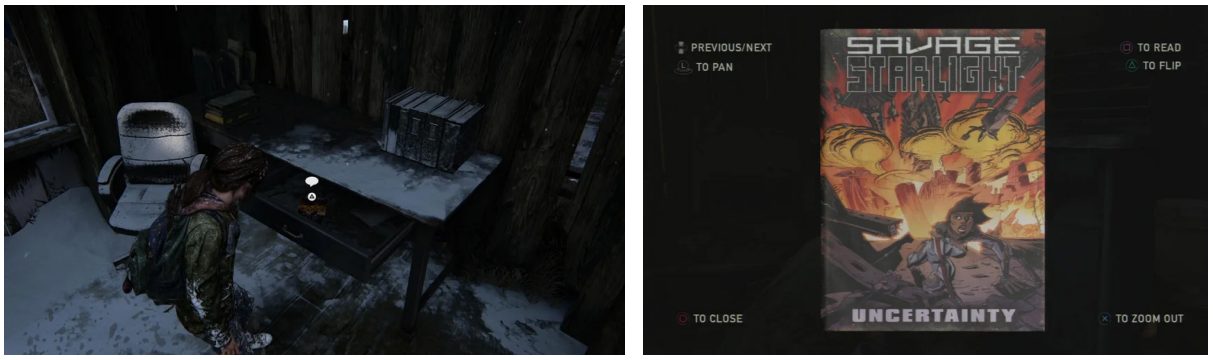
artifact to learn what happens next. If only real archaeology could provide such thorough evidence of events! Through learning of Ish's existence solely through fragments of items and environmental remnants, we argue that the player has exhibited a semblance of archaeological investigation.

It is also noteworthy that the game allows you to 'hold' these artifacts and investigate them in your hand. Having found a Firefly pendant, for example, players are then able to zoom in on the object, to read the text that is inscribed on it, and to turn it over to see its backside. This effectively allows players to 'study' the objects they find, which is similar to archaeological practice. During archaeological analysis, researchers examine objects for any potential clue as to their origin. This could be the manufacturer, the location, or the date range. Objects are changed or updated over time, providing archaeologists with sometimes clear date ranges for items. The PlayStation consoles, to use an appropriate example, have distinctive elements that allow us to recognize which edition we are holding. In archaeology this goes even further: glass bottles or jars, for example, often have embossing on the bottom that provides information on the manufacturer, location of manufacturing, and the date in which it was made. Still older, stone tools and ceramics can also often be analyzed and ascribed to a certain cultural group or date range. Video game settings and artifacts such as in *The Last of Us* can be treated in the same way to uncover more about the history of the events, locations, and people. Similar mechanics are also present in other games, including the *Uncharted* series (Naughty Dog, 2007–), *The Elder Scrolls V: Skyrim* (Bethesda, 2011), *Gone Home* (The Fullbright Company, 2013) or *The Forgotten City* (Modern Storyteller, 2021).

Additionally, it is important to point out that the archaeological mindset is not only operative within the players of *The Last of Us*. The game's characters, too, reconstruct the history of what they call 'the old times' throughout their journeys. At one point in *Part 2*, Ellie and her friend Jesse find the Seattle Conference Center, which still displays banners for the '2013 Comic Expo'. Both of them being born after the outbreak, and therefore unfamiliar with Comic Con-like events, Ellie and Jesse are not sure what to make of this. Jesse asks: "What's up with all these posters?" Ellie, a big comic book fan herself (*Part 1* had her find and collect comic books) replies: "It's a bunch of comics", and inquires further: "What was happening here?" Jesse estimates that this may have been a "gathering for people who were really into this stuff, like you [Ellie] basically." Ellie replies: "We were born in the wrong time, man." What is especially interesting here is the evoked feeling of dramatic irony, as the characters work to figure out something that we, the players, already know.

CONCLUSION

Throughout this chapter, we have demonstrated how Naughty Dog's post-apocalyptic vision of *The Last of Us*, *Part 1* and 2, utilizes and also promotes an



Ellie finds a comic book in *The Last of Us Part 1* (screen capture from the game).

implicit archaeological lens during play. The created setting depicts real world locations and events up to 2013, which are then aged 20 years and explored. Game developers create vignettes of lived experiences within the chapters that allow players to understand what living through the pandemic and post-apocalyptic setting would have been like for more than just the main characters. The players share Joel and Ellie's experiences of finding and interpreting artifacts and settings to learn more about this history. To be sure, this paper does not argue that *The Last of Us* represents 'actual' archaeology. Rather, we hope to have shown that the way in which the player engages the game world is somehow similar to archaeological practice.

We are, however, aware that this paper assumes a particular "implied player" (Aarseth, 2007; Zhu, 2015), or a specific mode of playing *The Last of Us*. The previous discussion relates primarily to the player who actively searches through the game world and takes note of the found letters or materials. Players may however also journey through the game without paying attention to these side collectibles. Much like the real world, the game offers players the option to learn more about the lived experiences of the Cordyceps pandemic, or to continue your journey without taking note of them. This is similar to actual historical sites (on the relationship between historical video games and heritage sites, see Mochocki, 2021), where visitors can engage with the site in large depth (e.g., reading informational plaques, taking notes, asking questions to guides), or more superficially (e.g., taking in the atmosphere of the site and not engaging with its historical aspects further). While the game's inclusion of these mechanics nevertheless legitimizes our reading of the game as a (possible) form of implicit archaeology, future scholarship could be interested in performing in-depth audience research into how larger groups of players play these games and adopt archaeological mindsets.

We would also argue that such gameplay mechanics, which we have considered as forms of implicit archaeology, could be usefully operationalized in the context of archaeology education. Much has been written in recent years on teaching history via historical video games (e.g., McCall, 2011) and while *The Last of Us* does not straightforwardly present any period of the historical past, the way in which it presents archaeology-like methods of analysis through world exploration and environmental or indexical storytelling may be used to inform students of archaeological methods of inquiry. While players do not become fully-fledged archaeologists upon completion of the game(s), they may have subconsciously picked up some knowledge about how history is reconstructed, considered and/or debated during their gameplay. Students could, for example, play a given level of the game and be asked to search for artifacts, write down their location and time of finding, note their external characteristics using the gameplay function that allows them to turn artifacts around in their in-game hands, in order to, finally, formulate hypotheses about the past of the in-game world.

Finally, we must point out that *The Last of Us* is not the only game with this sort of gameplay and mechanic for implicit archaeology, although it is more explicit than others. Many may point out game series such as *Tomb Raider*, *Uncharted*, *Assassin's Creed*, *World of Warcraft*, *Sid Meier's Civilization*, and more as archaeology-centered games. While they all deal with archaeology and replication of historical events, a 'true archaeological mindset' is not present. *The Last of Us* is, to our knowledge, one of the more appropriate video games that presents players with a vivid story containing hidden experiences that is left up to the player to examine, to relive, to interpret, and to experience (for other examples, such as the *Dark Souls* series, see Caracciolo, 2022). Some could go through the entire game without stopping to examine past lived experiences, but as far as *the Last of Us* is concerned, we are glad to have learned the story of Ish.

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My neighbor Linnaeus: The influence of Studio Ghibli in zoological nomenclature

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Characterized by its complex stories, stunning visual art, and strong female protagonists, Studio Ghibli is one of the most renowned studios in the animation industry. The Tokyo-based Japanese studio was founded by directors Hayao Miyazaki and Isao Takahata and producer Toshio Suzuki in 1985. Since then, it has been involved in different projects: short films, commercials, video games, and most notably, more than 20 feature films such as the classic *Grave of the Fireflies* (1988) or the Academy Award winner *Spirited Away* (2001) (Studio Ghibli, 2023).

It is undeniable that over the years, Ghibli has become a worldwide phenomenon. But its influence has not been limited to entertainment. We can also find traces of it in science, particularly in the one in charge of identifying, classifying, and naming species: taxonomy. In this contribution, I compile the animal species whose scientific names have been inspired by Studio Ghibli, as well as the stories behind the choice of those names.

A BRIEF INTRO TO NOMENCLATURE

Before we get started with the names, let's go back to what rules them: nomenclature. Nomenclature is the part of taxonomy that deals with the naming of species (Winston, 1999). It is a system that allows every discovered species to have a unique name based on specific rules (Winston, 1999, 2018). These rules, assembled into "nomenclature codes", vary depending on the type of organism to be named; for example, to name animals, we have the International Code of Zoological Nomenclature, while for plants, there is the International Code of Nomenclature for algae, fungi, and plants (ICZN, 1999; Turland et al., 2018).

Although humans have assigned names to organisms for thousands of years, it was not until the 18th century that the naming process began to standardize (Winston, 2018). The latter was possible thanks to the work of the Swedish naturalist Carl Linnaeus. Back in his day, scientific names were often long as they also served as descriptions of the species. Linnaeus had the idea to assign each species a two-word name in addition to the longer descriptive one and used it throughout his works. It did not take long for other scientists to adopt these binomial names as the preferred ones for their practicality, so much so that their use prevails today (Winston, 1999, 2018; Heard, 2020).

We can identify a species' scientific name as this two-word, most likely Latinized, label. The first word, always capitalized, is the genus name. It indicates the major group a species is most closely related to. The second word is the specific name, and it "qualifies" the first (Winston, 1999). This is the one that makes a name unique, as no other member in the genus can have the

same name. As we will see below, specific names can refer to different things, explicitly or implicitly: features of the species, places, people, or even nothing at all (Winston, 1999; Heard, 2020). Here, we will get to know a particular type of scientific names, the *ghiblicore* ones.

GHIBLI-INSPIRED SCIENTIFIC NAMES

From the Valley of the Wind

Nausicaä of the Valley of the Wind (1984), considered the first Studio Ghibli feature film, has inspired the names of two marine species: a parasite isopod and a sponge. The former's name is *Cabirnalia nausicaa* Boyko & van der Meij, 2018. This species was named after the film protagonist, Princess Nausicaä, since the structure that helps it attach to its crab host (attachment process) resembled the protective mask Nausicaä wears to enter the Toxic Jungle (Boyko & van der Meij, 2018) (Fig. 1). With a look at Boyko & van der Meij's study (2018: p. 16, fig. 8C), one can see the similarity.

Figure 1. The isopod *Cabirnalia nausicaa* with Nausicaä's flight helmet and Shohki mask.

Also named in honor of the princess, we have the sponge *Scopalina nausicae* Turner, 2021. Although the author of the species did not delve into the origin of the name when describing it, he did talk about it in a later interview (Turner, 2021; Tassof, 2021). Turner (2021) recalled that some creatures in the Ghibli film filter and enhance their environment (probably referring to the Ohmu) just as sponges like *S. nausicae* do in the sea, hence the name (Tassoff, 2021; Nausicaä Wiki, 2023).

Fuzzy species

The fuzzy spirit Totoro, from *My Neighbor Totoro* (1988), is the Studio Ghibli character that has inspired most of the species' names on this list. *Knebelia totoroi* Audo et al., 2014, a fossil lobster, and P*aravimus totoro* García & Villarreal, 2023, a harvestman, were named after Totoro due to the morphological similarities shared with him. For Audo et al. (2014), the margin of the body (carapace) of *K. totoroi* resembled the silhouette of Totoro. In the case of *P. totoro*, it was a pair of tubercles on its back, its paramedian armature, that reminded García & Villareal (2023) of Totoro's ears.

Other two species share their name with Totoro as well, the tardigrade *Pseudechiniscus* (*Pseudechiniscus*) *totoro* Gąsiorek et al., 2021, and the ant-like stone beetle *Stenichnus totoro* Jaloszyński, 2004. These animals received their names as a way to commemorate Totoro, without giving further explanations (Jaloszyński, 2004; Gąsiorek et al., 2021). Still, one could argue that their fluffy bodies, like Totoro's, played a role in this decision.

Finally, there is the velvet worm *Eoperipatus totoro* Oliveira et al., 2013 (Fig. 2). Unlike the rest of the Totoro-named species, the name of this species was inspired by another character in the film, the Catbus, "a many-legged animal" that, according to Oliveira et al. (2013), resembled the worm. It remains a mystery why this species was named "totoro" instead of "catbus" or "nekobasu", its Japanese equivalent. On the bright side, these names are still available for other species with multiple legs.

Figure 2. The velvet worm *Eoperipatus totoro* wearing a Catbus hat.

Spirits of the forest

Princess Mononoke (1997) has given rise to both epic characters and memorable scientific names. For example, the Scandinavian wasp *Odontocolon kodama* Johansson, 2022 is the namesake of a characteristic group of spirits in the film, the Kodama (Johansson, 2022) (Fig. 3). These little white creatures live in the trees and are a sign of the health of the forest; if the forest is destroyed, so are they (Ghibli Wiki, 2023a). Johansson (2022) mentions this in the etymology of the species' name, perhaps hinting that the same could happen to the "real-life kodama" if the forests where it lives are harmed.

Another species related to this film is *Ornamentula miyazakii* Minowa & Garraffoni, 2021. By reading the name in this context, one can immediately tell that this species of gastrotrich was named after Hayao Miyazaki. Nonetheless, there is a descriptive component apart from celebrating the talented director. According to Minowa & Garraffoni (2021), the gastrotrich looks like one of Miyazaki's characters, the Deidarabotchi or Night-Walker, the nocturnal version of the Forest Spirit (Ghibli Wiki, 2023b).

But not only the spirits in *Princess Mononoke* have inspired scientific names. For the name of the leech *Orobdella mononoke* Nakano, 2012, what brought the idea was a place. This Japanese species received the name "mononoke" because it was discovered in Shiratani Unsuikyo, the location that inspired the forest portrayed in the film (Nakano, 2012).

Figure 3. Top: The wasp *Odontocolon kodama*. Bottom: Kodama in the forest from *Princess Mononoke* (1997). Image sources: Barcode of Life Data Systems (H. Haraldseide; CC BY-NC-SA 3.0); Studio Ghibli (screen capture from the movie).

The No-Face cockroach

When a team of researchers found a new species without a face, they did not hesitate to give it a rather literal name: "kaonashi" (faceless in Japanese). *Cretaperiplaneta kaonashi* Qiu et al., 2020 is an amber-embedded fossil cockroach from Myanmar that lived in the mid-Cretaceous (approximately 113–105.5 million years ago) (Qiu et al., 2020). Since the only specimen found had its face damaged, the species was named after the iconic Kaonashi or No-Face, the silent spirit that follows Chihiro in the film *Spirited Away* (Fig. 4).

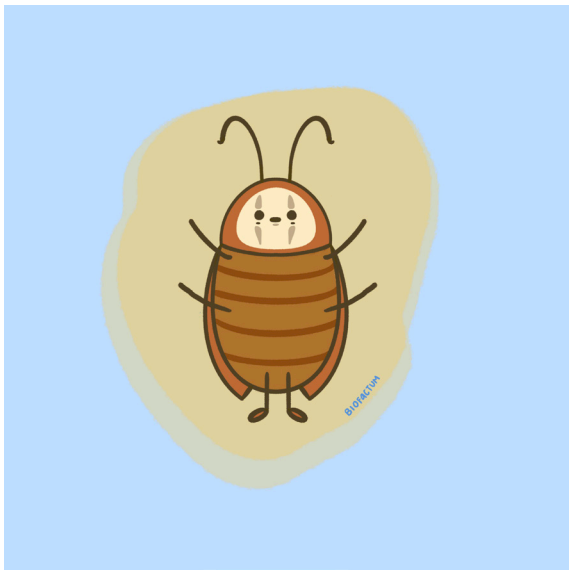

Figure 4. The No-Face cockroach *Cretaperiplaneta kaonashi*, embedded in amber.

An anemone with spark

The sea anemone *Stylobates calcifer* Yoshikawa & Izumi, 2022 is probably one of the most curious species with a Studio Ghibli-inspired name. It is so peculiar that it was listed as one of the ten most remarkable marine new species from 2022 (Dekeyzer, 2023). This Japanese animal can secrete a substance (carcinoecium) that allows it to adhere to the shell of the hermit crab *Pagurodofleinia doederleini* (Doflein, 1902), which becomes its moving home (Yoshikawa et al., 2022). *Stylobates calcifer* owes its name to the fire demon Calcifer from *Howl's Moving Castle*, a novel by Diana Wynne Jones (1986), later adapted into a film and popularized by Studio Ghibli (2004) (Fig. 5). According to Yoshikawa et al. (2022), the relationship between the anemone and the crab reminds that of Calcifer with the wizard Howl, both resulting in a "moving castle".

Brittle starfishy in the sea

Last but not least, there is the fossil brittle star *Stegophiura miyazakii* Ishida et al., 2018. This species was found in Mashiki, Japan, on a strata dating from the Late Cretaceous (approximately 100.5–66 million years ago). Ishida et al. (2018) named the species after Hayao Miyazaki, using his last name as the specific name. The authors decided to do this to honor Miyazaki's work in animation, particularly *Ponyo* (2008), a film where marine life plays a central role (Fig. 6). Moreover, the species' discoverers did not overlook that the director's favorite novelist lived in the same prefecture where the species was found.

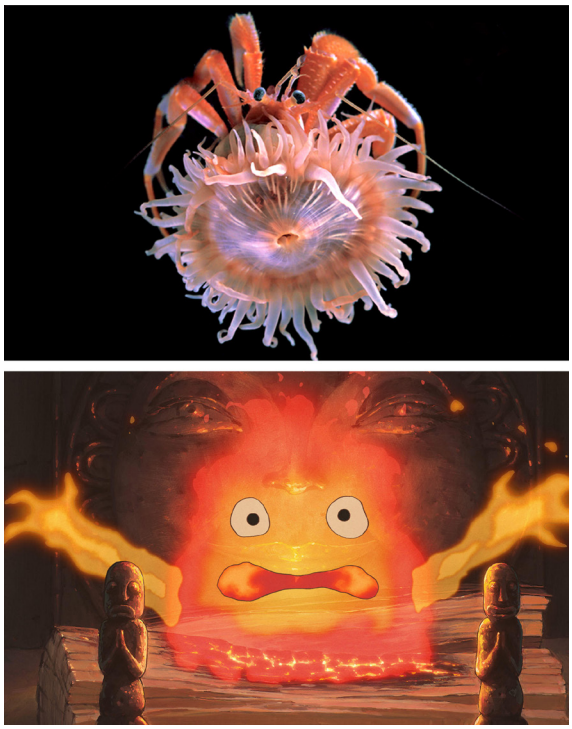

Figure 5. Top: *Stylobates calcifer* anemone and its crab host *Pagurodofleinia doederlini*. Bottom: The fire demon Calcifer from *Howl's Moving Castle* (2004). Image sources: World Register of Marine Species (A. Yoshikawa; CC BY-SA 4.0); Studio Ghibli (screen capture from the movie).

CONCLUSION

To date, Studio Ghibli has inspired the scientific names of 13 animals. These include both extant and fossil species from terrestrial and aquatic environments, all invertebrates. The number of Ghibli-themed scientific names has increased over the years, with one in the 2000s (Jaloszyński, 2004), five in the 2010s (Nakano, 2012; Oliveira et al., 2013; Audo et al., 2014; Boyko & van der Meij, 2018; Ishida et al., 2018), and seven so far this decade (Qiu et al., 2020; Gąsiorek et

al., 2021; Minowa & Garraffoni, 2021; Turner, 2021; Johansson, 2022; Yoshikawa et al., 2022; García & Villareal, 2023). Since the popularity of Studio Ghibli continues to rise and there are still millions (literally!) of species to be named, Ghibli names will almost certainly keep emerging.

Figure 6. Top: The fossil brittle star *Stegophiura miyazakii*. Bottom: Marine landscape from *Ponyo* (2008). Image sources: Ishida et al. (2018; CC BY-SA 4.0, modified); Studio Ghibli (screen capture from the movie).

The one thing that stands out the most about these names, apart from themselves, is their origin story or etymology. Within Ghibli names, we can find indirectly descriptive ones (e.g., *Cabirnalia nausicaa*), commemorative ones (e.g., *Pseudochiniscus totoro*), those which tell us stories (e.g., *Orobdella mononoke*), or a combination of these (e.g., *Ornamentula miyazakii*). Each reflects a great creative work, as they required the authors' ability to identify patterns between their new species and Studio Ghibli's works and link them together, all while having a little fun. For all current and future taxonomists, this is your sign to be ingenious and give your species a name worth remembering. If it is related to Ghibli, even better!

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FURTHER READING

If you are into peculiar scientific names and their etymologies, I recommend you the following:

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You can also find more about scientific names, accompanied by cute drawings, in **Biofactum** (@thebiofactum; https://www.instagram.com/thebiofactum/), where I am a collaborator.

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About the author

Karla J. Humara-Gil is a brittle star taxonomist and a biological nomenclature enthusiast. She grew up watching Studio Ghibli films, with *Princess Mononoke* as her favorite. Naming a species after a Ghibli character is now on her bucket list.

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Nazca Lines in *The Legend of Zelda: Tears of the Kingdom* — a game design and historical perspective

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In *The Legend of Zelda: Tears of the Kingdom* (Nintendo, 2023), the player can go on a quest to find and decipher numerous geoglyphs. In this study, we will discuss why these lines make their appearance in this game's design by comparing it to the previous entry, *Breath of the Wild* (Nintendo, 2017). We will also try to answer the question "Are the game's geoglyphs truly geoglyphs?". We will find out that from a game design perspective, the lines correct the main problem of the memory quest from *Breath of the Wild*, by making memories (named as "tears" in *Tears of the Kingdom)* more visible. I will also conclude that these lines are only slightly related to geoglyphs as the archaeological concept in terms of use, making and purpose, answering a certain definition.

This study contains no spoilers of *Tears of the Kingdom*'s story, apart from the specific side-quest that leads to this geoglyph search.

A POINTER ON NAZCA LINES

Geoglyphs are one of the most intriguing mysteries of all the time. If we apply the strict definition from the Greek, 'geoglyph' means literally 'engraved work, chasing on soil' (Valenzuela & Clarkson, 2014). The word 'geoglyph' was first used in 1949 by the Venezuelan archaeologist Josep Maria Cruxent and was further defined by Grete Mostny some years later (Valenzuela & Clarkson, 2014). This broad definition encompasses all type of glyphs, including recent creation by "land art". The most popular on that domain was Robert Smithson, a 20th century artist well known for his 'spiral jetty', immortalized in *Breath of the Wild* close to Akkala Higlands on the Rist Peninsula ("rawmeatcowboy", 2017). However, these cryptic line-shaped animals (Fig. 1), characters or other representations, obey a more precise definition in terms of purpose, as argued by Valenzuela & Clarkson in their 2014 study (Valenzuela & Clarkson, 2014).

Figure 1. Condor-shaped geoglyph, one of the most well-known geoglyphs found in Peru. Source: Wikimedia Commons (Robert Canals).

Their definition is interesting in three ways, as they mentioned presence of geoglyphs "all around the world" which have "independent origins and development in

time and space". If we focus our analysis on Nazca's figures made between 150 BCE and 600 CE (ISSY TV, 2020), it is really important to know that geoglyphs can be found everywhere else. Famously, some are depicted in India (Valenzuela & Clarkson, 2014; Lambers, 2020; Oetheimer & Oetheimer, 2021), United States, and United Kingdom, as the Cerne Abbas Giant found in Scotland and immortalized in the game *Pokémon Sword/Shield* (Game Freak, 2019) (Hoffer, 2019). Nazca's geoglyphs are found in a region of coastal Peru called Chala, 400 km south of Lima in a desert region of the Ica department, but some of the figures have been lost definitively because of various reasons, such as urbanization. Those geoglyphs were made by removing or clearing sand and stones (or sometimes adding stones), which creates contrast between the figure and the ground and thus, enhances visibility (Valenzuela & Clarkson, 2014). Their creation is accomplished by using ropes and sticks, allowing Nazcans to build a larger version of a prototypical figure. That is why some geoglyphs are made in a gigantic proportion with ease.

The purpose of the visibility of these figures is still a subject of discussion in the archaeological community, as it seems that each of them had a different purpose. But earlier hypotheses made in the 1930s by Peruvian archaeologist Toribio Mejía Xesspe are not so fantasist (ISSY TV, 2020). He mentioned their specific orientations to mountains, aqueducts and also cemeteries. Some of them had entrances and exits where people came to these figures for making ceremonies and rituals dedicated to the gods. Other geoglyphs connected two major settlements, and those traced on the mountain slopes functioned as signposts visible to pedestrians and those crossing the desert (ISSY TV, 2020). The layout of a geoglyph could also have been used for political purposes, to mark a territory and its politico-religious appropriation. The larger they are, the more powerful you are. Some set of geoglyphs could even be related. No matter the purpose, their orientation seems to be the most important thing.

Very well-known for their gigantic spider, bird shaped figure, and other represented animals, Nazca's geoglyphs are more varied than they seemed at their first discovery. Some are huge, reaching hundreds of meters, while others are only 10 m long (Bacha, 2012; Valenzuela & Clarkson, 2014; Erreca, 2018). The first mention of a geoglyph was by the chronicler Piedro Cieza de Léon in 1552. But we had to wait until the 1930s to discover the entire complexity of the lines, from the ground up to seeing them from the sky. An interest personified by Maria Reiche who spent all her life studying and protecting geoglyphs (Bach, 2012).

Today, new AI/drone-based technologies allow archaeologists to find more geoglyphs, notably covered by dust and other desert elements. In December 2022 (Sakai et al., 2023), a consortium of Peruvian and Japanese archaeologists (Yamagata University, 2022) found a whopping 168 new lines depicting animals for the most part. In June 2023 (Richter et al., 2021), four new geoglyphs were found by the same team using a deep learning method. These small figures could have a different purpose than the larger ones previously presented.

GEOGLYPHS IN VIDEO GAMES

Video games that reference geoglyphs directly are very rare. Some of them reference them in the background, as *Pokémon Sword/Shield* previously mentioned. One of the notorious examples is *Illusion of Gaia* (or *Illusion of Time* in PAL territories), an action-RPG (role playing game) made in 1994 by Quintet for the Super NES. In the game, you discovered several mythical locations (Mu, Angkor Vat, Babel Tower, etc.) and one of them is a Nazca Line, much more precisely, a condor-shaped one in the 'Inca country' named 'Nazca painting' (Fig. 2). The characters of the game are wondering how such lines could have been drawn. Kara, a protagonist, even wonders if the Incas organized sports events using them. A little later, Erik, the main protagonist, wonders if

he hadn't already seen that shape, which for him is more reminiscent of a swan than a condor, to which Neil replies that what they perceived as a swan was probably a condor for the Incas. Thanks to this reflection, one of the members of the group deduces that the location of the stones present in the geoglyph matched the location of the stars in the constellation of the Swan (Cygnus), which, once the enigma had been solved, gave them access to another mystical location, the 'Celestial Garden'.

Figure 2. Erik and his friends discuss in the middle of the Geoglyph in *Illusion of Gaia* [a.k.a. *Illusion of Time*] (Quintet, 1994). Screen capture from the game.

The second game is also an RPG, from Owerworks (2000) for the Dreamcast, *Skies of Arcadia*. This game is also an ode to world discovery and is thus littered with discoveries. One of them is called 'The Great Bird' (Fig. 3) and it is also a representation of the Nazca geoglyphs, found in the province of Ixa'Taka, which is based on the representation of Mesoamerican peoples. The description of the Great Bird tells us several things. Firstly, there is the hypothesis that the animal geoglyph functioned as a calendar, its wings and tail indicating the equinoxes. That hypothesis seems to be incorrect for real geoglyphs, according to a 2021 study (Richter et al., 2021). And secondly, we learn that the figure of the bird was not the only one, but that the others were swallowed up by the expansion of the forest, which did not allow them to be preserved – contrary to Nazca's geoglyphs that were made in arid regions, far from the forest, and were thus more easily preserved.

GEOGLYPHS IN *TEARS OF THE KINGDOM*

In *Tears of the Kingdom*, the country of Hyrule has been covered chockfull with geoglyphs. These geoglyphs have a certain importance to the story as they tell (in the order where the player discovers them) what happened between Link and Zelda at Hyrule Castle's depths and his awakening at the beginning of the game. To find these short pieces of storytelling, the player needs to find a drop of water hidden inside the geoglyph, which represents in itself a dragon's tear; there are eleven in total to collect, plus an extra one.

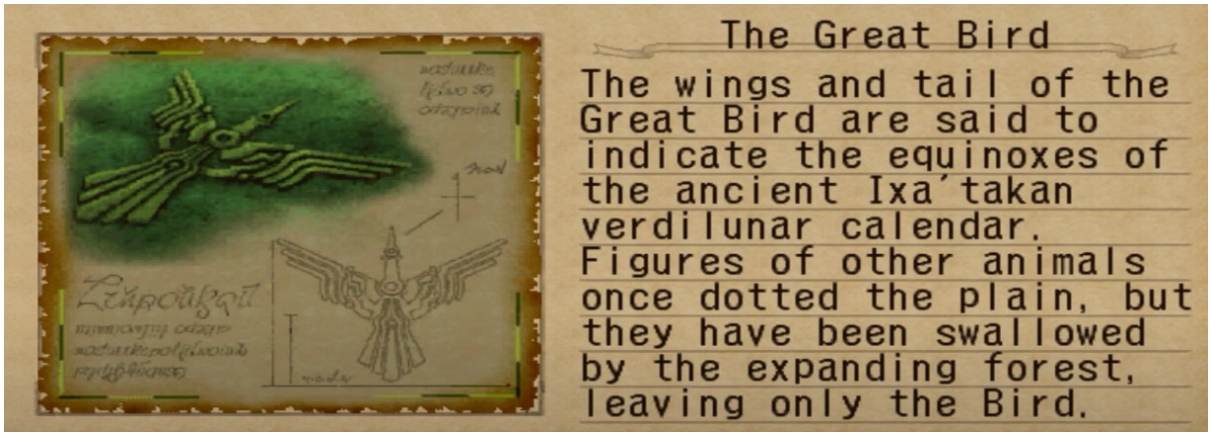

Figure 3. Description of 'The Great Bird' in *Skies of Arcadia* (Overworks, 2000). Screen capture from the game.

Figure 4. Based on the "critical path", the first geoglyph you will discover is Rauru's Geoglyph. A difference of colors in that figure indicates the presence of the tear. Screen capture from the game.

Normally, the first place you see a geoglyph (if you follow the "critical path" of the game) is close to Sallari Hill on Central Hyrule where the player encounters Impa for the first time. She used to be the ruler of Kakariko village in *Breath of the Wild* (*Breath of the Wild* and *Tears of the Kingdom* take place in the same world with the same landmarks and several returning characters). Impa is now in the pursuit of all these lines that appeared in the kingdom. The first time you meet her, you need to repair her hot-air balloon by using the power 'ultrahand', fully exclusive to *Tears of the Kingdom*. After that, she let you ride the balloon with her and you fly over the geoglyph that represents Rauru (Fig. 4), one of the most important characters in the backstory of this game.

Finding that tear triggers another dialogue where Impa says there is something to do close to Tanagar Canyon, in the Forgotten Temple. In this next place, you will find a mural where you can see all the geoglyphs that you need to find, as well as a map to locate them (Fig. 5). After that, it is up to you to find them or not. It is also here that the player can find the right order to make it coherent story-wise, as each figure depicts a pretty important memory. Impa's quest, as many other quests in *Tears of the Kingdom*, is optional.

In *Tears of the Kingdom*, geoglyphs are huge. You can see them from far away, especially at night. These figures depict some important characters (Rauru, for instance), objects (Master Sword, the legendary sword of the series) and even (but that's the corporate side of Nintendo) a Nintendo Switch (or could be the Pru'ha/Sheikah Slate that has the same shape). You can find them on the ground but also on cliffs or mesas, and even on snowy mountain. This is a clever extension to the Zonaï Tribe's lore from which Rauru came from, as their architecture and statues were inspired by the pre-Columbian period. As previously said, you can find a dragon's tear, a fragment of memory of a very distant past in each of them.

This is the same as in *Breath of the Wild*, in which memories could be found thanks to pictures you find in your Sheikah Slate (Fig. 6): again, twelve pictures (plus one extra) depict locations. While some are pretty easy to locate because of topography or geology, others were more complex to reach as they depict a distant past one hundred years be-

Figure 5. Location map of geoglyphs found in the Forgotten Temple. Screen capture from the game.

fore *Breath of the Wild* takes place. Some locations underwent the test of time as some houses, ruins or others things do not exist anymore. That is why some players decide to face this quest by searching some of the places on the Internet.

To avoid replicating that mistake, we can imagine that the developers of *Tears of the Kingdom* made the great figures easier to find. If they want to focus on that quest, they can easily follow them up until they find a tear (or in some cases a korogu, a small plant-like creature that gives you a seed). Leaving a map in the Forgotten Tem-

Figure 6. In *Breath of the Wild*, the player needs to find precise locations following some pictures. Each location contains a memory. Screen capture from the game.

Figure 7. Flying or gliding is one of the easiest ways to find geoglyphs. Screen capture from the game.

ple is also a way to help players find the figures without much head-scratching. This method is another trick that Nintendo's developers used to lure in the player.

Additionally, *Breath of the Wild* uses a triangle's method to capture the player's focus and let them find their way in the huge game environment. That verticality is expressed by a fine-tuned world/game design where the player can be constantly called by their curiosity. *Tears of the Kingdom* uses that method but on a horizontal look for geoglyphs. Or almost, because the player can find the geoglyphs pretty easi-

Figure 8. Geoglyphs can be seen from a very long distance, notably at night. Screen capture from the game.

ly from the sky. One of the main additions over *Breath of the Wild* is Link's ability to go high in the sky (and underground but that doesn't matter in our case). By using Pruha's tower or sky islands, Link can see geoglyphs from a large distance (Figs. 7, 8). He can also use his tablet to pin them with a symbol as a progression mark. With all that stuff, it is pretty easy to locate and finish what a lot people considered as one of the most important side-quests of the game. By using all these tricks, old ones but also new ones, developers made that quest more attractive than the previous one in *Breath of the Wild*. Let's now find out if these figures are like real Nazca's geoglyphs in the archaeological sense.

CAN *TEARS OF THE KINGDOM*'S GEOGLYPHS BE CONSIDERED AS REAL ONES?

As we saw earlier, there are two purposes behind the geoglyphs in *Tears of the Kingdom*: developing the story about Zelda and Link's separation, and awakening the hero. But you need to find these geoglyphs and it is precisely the main use of the figures: locate them. In a sense, *Tears of the Kingdom* is pretty close to reality, as real geoglyphs served to indicate some locations like temples. But they aren't just road signs. *Tears of the Kingdom*'s figures do not function like that. In fact, the thing they want to indicate is inside the geoglyph itself, not close to it. As we now know, none of the real geoglyphs depicted history of some kind in a regular way. The people who created those glyphs transmitted their history, myths and legends by oral tradition, not by writing (Bacha, 2012; Valenzuela & Clarkson, 2014; Erreca, 2018). But in some of them, we can find some artifacts as pottery or other crockery as gifts to the gods during celebrations. These objects say a lot about the people, the god they worshiped, and the process of that tradition.

But Nazca's geoglyphs are pretty restrictively made, as seen earlier. Two methods were generally used in the intricate process of making them (Valenzuela & Clarkson, 2014; Lambers, 2020), aiming to create contrast between clear and dark soil and rocks. Soil is made of numerous strata. By removing the clearest one and accumulating it on

Figure 9. On the ground, geoglyphs are "drawn" with a kind of fluorescent texture. That completely differs from real geoglyphs. Screen capture from the game.

the side of the hole to create a wall, establishing a color alternance that is the key to see contours of figures. In *Tears of the Kingdom*, it is pretty well illustrated as clear and dark grass or green substance alternate each other to create figures that could be seen better at night (Figs. 8, 9). But that's the thing. In fact, no rocks are used in any of *Tears of the Kingdom*'s geoglyphs, even when they are made on a mountain. They use a fluorescent-like substance to prop up the figures, sometimes added to grass (Fig. 9). There are no signs of ground removal or anything like it. Places where geoglyphs were made are also archaeologically incorrect because the glyphs in the game are found in diverse locations such as beaches, plains, mesas, and snowy mountain. Ironically, none of them are found in an arid region like the Gerudo Desert.

CONCLUSION

Tears of the Kingdom's lines are a very good way to correct one of the small complaints players had about Breath of the Wild "memory quest" by making them visible and well-integrated in the overall game and narrative design. However, the term 'geoglyph' could be extracted out of context as 'geoglyph' answers to a certain strict definition. In that way, their purpose, use and making are slightly out of the history and respond more to a lore, game and level design perspective than a real appreciation by Nintendo of actual glyphs.

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FURTHER READING

Check out the publications by the Programme Archéologique Animas Altas, available from: http://paracas.ehess.fr/publications-paaa-ip/

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The snails of *Super Mario Bros. Wonder*

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Nintendo has recently released a new Mario game, *Super Mario Bros. Wonder*, a multiplayer platformer involving a good dose of mushrooms, both in-game and presumably during development. But psychedelic trips aside, in the first few stages of the game we are introduced to a completely new (and arguably the best) "enemy" in Mario games: a snail with a fabulous pink shell.

Figure 1. Snail (©Nintendo, 2023; fair use). Source: Super Mario Wiki (https://mariowiki.com/).

So far, this critter remains unnamed, but the Super Mario Wiki refers to it as Snail, with a capital S. So, I will use this name throughout this article. It's not very creative, I agree, but maybe safer than risking a bad pun like in some Pokémon names.

The Snail has a pink shell and a green soft body. Its tentacles are striped and its eyes are located below the tentacles. Overall, it is a cartoonish design – as it should be – but an interesting one nevertheless. First, it's kinda cute. Secondly, it has some curious features that are an excuse for me to discuss a little bit about real-world biology. So, let's get down to the snail science.

SNAIL BIOLOGY

Mario Wonder's Snail is a land snail. Land snails are part of the Class Gastropoda, alongside freshwater snails, marine snails, terrestrial slugs, sea slugs, and an assortment of other animals often referred to by more specific terms such as abalones and sea butterflies. Gastropods, in turn, belong to the Phylum Mollusca (the mollusks), together with squids, octopuses, clams, oysters, mussels, and many other shelled and shell-less animals.

Besides the regular Snail in *Mario Wonder*, there is also a large version of it, dubbed Big Snail. It is a magnificent beast larger than the human characters in the game. Its design is exactly the same as the small Snail, although it looks like it's deeply annoyed by your presence – which is understandable, as anyone would be annoyed by an Italian-American plumber running around your place, jumping, and damaging the brickwork.

In nature, a snail unfortunately cannot grow to a large size for two main reasons: (1) the shell would be very expensive to

Figure 2. A giant tiger land snail, *Achatina achatina*, from Ghana. Source: Wikimedia Commons (C.J. Sharp, 2017).

produce in terms of calcium carbonate (and energy) and it would become too heavy to carry around. Typically, aquatic animals are larger because water partially sustains their body weight. Life on land is not so easy. And (2), snails need to stay hydrated. They lose water to the environment through their skin, via evaporation. A larger body would mean more surface for water to evaporate from. Besides, they use a lot of water to produce mucus, which we will come back to in a minute.

Still, some snails in tropical habitats can attain respectable sizes. One species of African giant snail, *Achatina achatina* (Fig. 2), holds the Guinness World Record, with a shell measuring 27 cm in length (see Salvador et al., 2021, for more on giant snails). But there is an extinct species whose shell is estimated to have reached 30 cm. It is called *Pebasiconcha immanis* and it lived in the area that is now the Colombian and Peruvian Amazon during the Miocene epoch, from circa 16 to 10 million years ago (Wesselingh, 2006).

But are Big Snails the adult version of the small Snail? It doesn't look like it, because the shells of both the small and Big Snails have the exact same number of whorls (two). When a young snail grows, its shell grows along with it by slowly adding more material to its edge; thus, the number of whorls slowly increases. For instance, certain African giant snails (genus *Achatina*) are born with around 2 whorls on their shells, but the adults can have up to 7 or 8 whorls. So, could the small Snail and Big Snail be two different species then? Perhaps, but regrettably we don't have enough evidence to answer that question yet.

In *Mario Wonder*, you can find Snails crawling around on the ground and vertical surfaces (but not the ceiling as far as I could tell from my playthrough). Real snails can do that – and even hang upside down – because the slime (or mucus) they produce has adhesive properties. In fact, snails produce slimes with various purposes: (1) for movement, as they "glide" atop it; (2) for hanging on to surfaces, as we've seen above; (3) for "hygiene", as the slime can have antibacterial properties; and (4) for protection, as some types of slime can be used to ward off predators. When moving, a snail leaves a trail of slime behind it (Fig. 3), though this cannot be seen in *Mario Wonder*. Their ability to move vertically on pipes and other surfaces implies that they also produce mucus.

In the game, the Snail can go inside pools made of poison. Needless to say, real snails cannot do that (although some species of

Figure 3. A *Cochlicella barbara* snail leaves a silvery slime trail as it moves. Source: Wikimedia Commons (snail ho, 2007).

land snails can venture into shallow water) and are not immune to poison. On the contrary, most species of snails do not cope well with pollution. Therefore, these animals make good bioindicators, that is, species that researchers can use to assess the health (or lack thereof) of an ecosystem (Gerlach et al., 2013). Regular presence of those snail species would mean a healthy ecosystem, while reduced numbers or absence of snails would indicate a polluted environment.

SNAIL MORPHOLOGY

The in-game design of the Snail's shell is stylized: it is a very rotund shell (Fig. 1) with an aspect that looks a bit "off" when compared to real-world land snail shells. Round shells like that are more commonly found in aquatic environments. But I'm not going to get too hung up on that as it is a cartoonish design. However, the shell color was an interesting – if weird – choice, and perhaps can be explained with a real-world example.

Figure 4. Shells of the grove snail *Cepaea nemoralis*, from Europe. This species is very variable in terms of coloration and lots of shell colors and patterns are known. Some of the red shells can attain a more pinkish tone. Source: Helmholtz-Centre for Environmental Research, UFZ (A. Künzelmann, 2011).

The shell is vivid pink. There are several real-life species with red to pinkish-red tones on their shells (for example, Fig. 4), but actual pink is not really a thing.

But there's a catch. If you search online for "pink snail" you'll run across one species called *Calocochlea festiva*. Sometimes you'll find it under the outdated names *Calococh-*

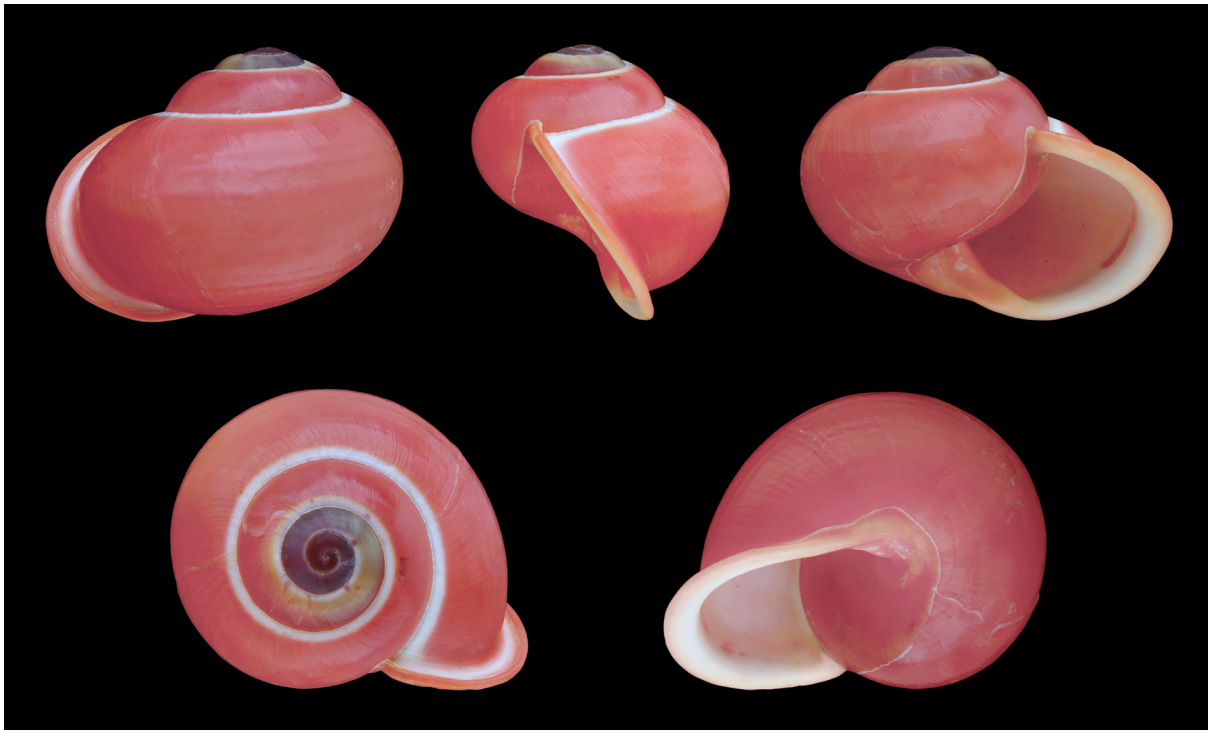

Figure 5. A shell of *Calocochlea festiva* seen from various angles. The shell is about 40 mm wide. Source: Wikimedia Commons (H. Zell, 2011).

lia festiva or *Helicostyla festiva*. It is from the Philippines – a country which has some of the most beautiful snails in the world – and it is fabulously pink indeed (Fig. 5).

The shell of *Calocochlea festiva* is a favorite among shell collectors due to its color. But that color is actually kind of a lie. The pink color is not visible on a live animal, because it is covered (like in all snails) by a protein layer called 'periostracum'. In nature, you'll find out that *Calocochlea festiva* has an orangish-brown color (Fig. 6), with some white stripes. In Figure 7 you can see a specimen with part of the periostracum remaining (on the top half of the shell) and part scrapped clean (the bottom half). Although many collectors prefer to have specimens that really represent the animal as it is in nature (in this case, brown), some will go for the showy (and often artificially modified) specimens.

In all likelihood, the designers of *Mario Wonder* based their Snail on periostracum-less shells of *Calocochlea festiva.* Note that the "border" of the shell that comes in contact with the Snail's soft body is white (Fig. 1), the same as in *Calocochlea festiva* (Figs. 5–7).

That "border" of the shell is known as the 'lip' (or 'peristome', to use the more scientific term). It is indeed quite common for the lip to be of a different color from the rest of the shell; white, soft pink, dark brown, and black, are common colors for the lip.

Figure 6. Shells of *Calocochlea festiva* showing intact shells. Source: Wikimedia Commons (Naturalis Biodiversity Center, 2015, cropped).

Now, let us move on to the flashy green soft body of *Mario Wonder*'s Snail. A green

body is rather uncommon in nature, but there are a handful of examples of it where varying tones of green are represented. For instance, the soft body of *Leiostracus perlucidus* from Brazil is light green (Fig. 8; its shell is actually whitish and translucent), while that of *Rhinocochlis nasuta* from Borneo has a more vivid green color (Fig. 9) that is more similar to *Mario Wonder*'s Snail.

Figure 7. A shell of *Calocochlea festiva* seen from various angles. The brownish periostracum layer has been scrapped off in half the shell to show the pink color underneath. Source: Forum Francophone des Collectionneurs de Coquillages (©KhanShells, 2012).

The eyes of *Mario Wonder*'s Snail are positioned below the head tentacles (Fig. 1). The position of the eyes is a very important feature in distinguishing between the main kinds of land snails. Land snails are not a single cohesive biological group like, for instance, birds (Class Aves). Rather, there are several different and unrelated lineages of gastropods that independently colonized land during their evolutionary history. Thus, the term 'land snail' actually designates a mix of biological groups, like, for instance, the artificial group of 'flying animals', which would contain most but not all birds, bats, pterosaurs, and insects.

Figure 8. *Leiostracus perlucidus*. We can see the green color of the soft body through its translucent shell. Source: iNaturalist (observation #12194810; ©F. Mendes, 2015, CC BY-NC 4.0, cropped).

Figure 9. *Rhinocochlis nasuta*. Source: iNaturalist (observation #22647153; ©N.L. Finley, 2019, CC BY-NC 4.0, cropped).

There are about 25,000 species of terrestrial gastropods living all around the world except Antarctica (Rosenberg, 2014). These species belong to the three largest subclasses of Gastropoda: Neritimorpha, Caenogastropoda, and Heterobranchia. Members of each lineage are only remotely related to those of another lineage (such as ourselves in relation to frogs, for example). Inside the latter subclass (Heterobranchia), there is a

group called Stylommatophora.

The Latin names do not matter much, but it is important to know that Stylommatophora contains over 80% of all terrestrial gastropod species in the world. Thus, they are typically what people are thinking about when they use generic terms such as "land snails/slugs". A distinguishing feature of Stylommatophora is that they have two pairs of tentacles on their head. The topmost pair are actually eyestalks, with the eyes positioned on the tip of the tentacles (by the way, that is the meaning of the Latin name Stylommatophora). The bottom pair of tentacles is responsible for the senses of smell and touch. If you take a closer look at the green snail in Figure 9, you can see the eyes (tiny black dots) on the very tips of the tentacles.

Figure 10. An example of an operculate snail: *Aperostoma blanchetiana*, from Brazil. Note that there is a lid-like structure atop the animal's "tail" – that is the operculum. When the animal retracts its soft body into the shell (bottom image), the operculum closes the shell aperture, offering extra protection against predators and desiccation. The shell is about 23 mm wide. Source: Salvador et al. (2018: fig. 4C, D).

All the other land snails (not Stylommatophora) have a single pair of tentacles and their eyes are positioned on the base of those tentacles (Fig. 10). Thus, we could surmise that *Mario Wonder*'s Snail is not a Stylommatophora. However, it could be interpreted as a terrestrial Heterobranchia that is more closely related to pulmonates but definitely not a pulmonate. That is because members of the other subclasses (Neritimorpha and Caenogastropoda) have an operculum, which is a structure that serves as a lid to close the shell when the animal retracts inside (Fig. 10). *Mario Wonder*'s Snail clearly does not have an operculum (Fig. 1), so it cannot be one of those.

SNAIL SHELLS

A recurrent issue with 2D and 2.5D games is mirror images. Take the most common example: when a character turns around to face the other direction, its sprite or model gets mirrored, making weapons or other items switch hands. So, a character might be right-handed while facing the right side of the screen and left-handed while facing leftward.

The same happens with the Snail. Snails are rather unique in nature in that their body is not symmetrical. The shell coils around while growing and the end result is clearly asymmetrical. The vast majority of shells in nature are right-handed (or dextral), meaning that when we look at a shell while facing its opening (aperture), we can see the opening to our right side (Fig. 11: top). Some species, however, have left-handed (sinistral) shells (Fig. 11: bottom). Try taking a look at all the photos in this article so far and figuring out if the shells are right- or left-handed.

Sometimes, a left-handed snail can even be found in a species that is typically right-handed. For instance, the garden snail Jeremy (Fig. 12) made the news a while ago for being left-handed and even got its own Wikipedia page. Left-handedness can either be genetically determined or, as in Jeremy's case, due to an accident during its early development.

Figure 12. Jeremy (top) and Bree (bottom). Jeremy is a rare left-coiling garden snail (*Cornu aspersum*). Notice how Jeremy's shell is a mirror image of Bree's typical right-handed shell. *Cornu aspersum* is a Stylommatophora snail, by the way, and all animals in this group are hermaphrodites. Source: Wikimedia Commons (Angus Davison, 2016).

When Snail or Big Snail turns around in the game, the handedness of the shell changes from left to right and vice-versa. Granted, most people will not even realize this, but for me, that is rather unsettling. I hope you will now notice this in the game and join me in becoming uncomfortable with it. By the way, when the Snail is seen from above (like when they are crawling on a pipe or other surface), their shells seem to have two spires, one to each side of the body, which is physically impossible in a natural shell. So, I'll just ignore that and pretend it never happened.

Still on the topic of shells, when Mario, or one of his heartless companions, stomps a Snail, the soft body of the animal is launched out of the shell. The Snails in the game survive this gruesome violence and then pitifully try to get back to their shells, as a last and feeble attempt at survival. Mario and company can use Snail shells like Koopa shells to rain more violence upon the local fauna and flora.

Now, I am aware that what I am about to say is obvious to most, but I feel like I need to address it here because many people (including other scientists) have asked me this. So here it goes. No, a snail cannot remove its own shell and then put it back on again. Both the shell and the soft parts make up the snail's body; the shell is the snail's skeleton. If, for any reason, the soft body is separated from the shell, the animal will not survive.

Honestly, I am not sure where the idea that the shell is a removable "accessory" comes from. Could it be from cartoons we watched as kids? Or maybe people are just mixing up snails (a mollusk, Phylum Mollusca) with hermit crabs (a crustacean, Phylum Arthropoda)? Hermit crabs, like all crabs, have a carapace (exoskeleton) made of chitin. However, hermit crabs seek out empty shells that once belonged to (that is, were part of the body of) a snail, which is typically a marine snail. When the crab finds a shell of suitable size and sturdiness, it wears the shell as an armor, so to speak (Fig. 13).

Figure 11. Top: The right-handed shell of *Satsuma longkiauwensis*, from Taiwan, seen from different angles. The shell is about 40 mm wide. Source: Wu et al. (2007: fig. 2, cropped). Bottom: The left-handed shell of *Satsuma squamigera*, from Taiwan, seen from different angles. The shell is about 20 mm wide. Source: Hwang & Wu (2018: fig. 2, cropped).

But you might say "Okay, but what about slugs? They have no shells." That's true, simply put, the definition of a slug is that they lack shells. I have often heard that "a slug is a snail who lost its shell." Taken literally, that is incorrect, as we have seen above. Slugs are born like that; they never had shells. Still, in evolutionary terms, that sentence has a kernel of truth behind it.

Slugs belong to the Stylommatophora group that I mentioned above or to families closely related to them. They descend from lineages of snails in which the shell was gradually lost throughout the course of their evolutionary history. A snail shell protects the animal's internal organs and it is a defense against predators and the environment (mostly water evaporation).

Figure 13. The armed hermit crab, a.k.a. black-eyed hermit crab, *Pagurus armatus*. Hermit crabs hide the softer part of their bodies inside a snail shell for protection. Source: Wikimedia Commons (NOAA Fisheries, 2021).

Figure 14. The European black slug *Arion ater*. Source: Wikimedia Commons (Prashanthns, 2008).

However, Evolution can work some weird stuff. In some cases, it might be advantageous for individuals to have smaller shells; for instance, that might make them more mobile, agile or faster (comparatively, of course), and thus give them an edge in escaping and hiding. Natural selection can act upon that and those individuals survive more and reproduce more, passing on their small-shell genes to the next generation. Over millions of years, the shells become so tiny that they are internalized into the body or altogether lost. That evolutionary

process resulted in the slugs we see today (Fig. 14). Many (but not all) slugs still have vestiges of the shell, like a small shield-like structure located inside the body.

ZOMBIE SNAILS

There is one feature of *Mario Wonder*'s Snail that I have not addressed yet: its striped tentacles. That one is a bit disturbing, so I left it for last. Striped tentacles are not a natural thing in real-world land snails. Rather, they indicate that the poor snail is infected by one of the most horrible parasites known.

It is a flatworm called *Leucochloridium paradoxum*, a.k.a. the green-banded broodsac, a name that reflects its striped color pattern. This flatworm species lives in Europe, Russia and Japan and infects snails exclusively belonging to the amber snail family (Succineidae). Further species in the genus *Leucochloridium* are also snail parasites, but they have different colors and patterns (see Nakao et al., 2019 for some examples).

The snails are intermediate hosts of these parasites. That means that the parasite undergoes its development inside the snail, but will then infect another animal (the definitive host), inside whom they will reproduce.

Like many parasitic infections, it all starts with the snails inadvertently ingesting worm eggs. Inside the snail's body, the eggs hatch into "larvae" called miracidia. The miracidia move to the snail's hepatopancreas (an organ that is more or less like a liver and pancreas put together), where they develop into their next life stage, called sporocyst. The sporocyst, in turn, will develop a green-banded broodsac that occupies the interior of the snail's eyestalks.

The broodsac is a flashy pulsating thing that looks like a caterpillar (Fig. 15). And who loves caterpillars? Birds. Thus, the parasite manipulates the snail's behavior, making it crawl towards places where it is more conspicuous – and hence, more easily snatched by birds. Birds are the definitive host of *Leucochloridium* and become infected after eating a parasitized snail. The adult flatworms live in the bird's cloaca and release their eggs together with the bird's feces, starting the cycle anew.

Figure 15. An amber snail (*Succinea* sp.) from Japan, infected by *Leucochloridium paradoxum*. You can clearly see the pulsating green-banded broodsac inside the right eyestalk. Source: Nakao et al. (2019, cropped).

If that sounds like the plot of a horror movie to you, it's because lots of B- sci-fi and horror involve "zombifying" parasites. *Leucochloridium* is just one of many such parasites. Most horror and sci-fi favor viruses as their "stars", but sometimes we see parasitic animals too, albeit typically fictional like the arthropod-like 'plagas' in *Resident Evil 4*. We can find a good example of a sci-fi parasite based on a real organism in *The Last of Us*. In that case, the zombifying parasite is neither a virus nor an animal, but a fungus belonging to the genus *Cordyceps* (see Villa & del Negro, 2022 for a nice biological overview).

So, is *Mario Wonder*'s Snail parasitized? I certainly hope not. It doesn't look even remotely similar to an amber snail, so it should not become infected by *Leucochlo-*

ridium. Still, I have to admit that the Snails do crawl around very conspicuous places, which makes them more likely to be stomped. That begs the question: if there is a parasite involved, are plumbers its definitive host?

FINAL THOUGHTS

In conclusion, the Snail is now my favorite enemy critter in Mario games (sorry, Chomp). But jokes aside, it is always good when animals that are not mammals are featured in games and other media. Putting them just a little bit in the spotlight allows people to see that the diversity of life is truly wondrous – and that it goes well beyond the usual boring stuff like lions and pandas that we are accustomed to seeing on the TV or at the zoo. Having more contact, even if virtual, with those fascinating creatures might lead some of us to try and save what's left of nature.

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FURTHER READING

Here are some approachable books for anyone interested in snails. They do not require any background in biology, so they are great starting points.

- Brooks, R. (2013) A Slow Passion. Snails, my garden, and me. Bloomsbury, London.
- Gordon, D.G. (2010) The Secret World of Slugs and Snails. Life in the very slow lane. Sasquatch Books, Seattle.
- van Dooren, T. (2022) A World in a Shell. Snail stories for a time of Extinctions. MIT Press, Cambridge.

And for the budding snail aficionados, the book *Slugs and Snails* by Robert Cameron (2016, Willian Collins, London) is an excellent and more technical introduction to this amazing group of animals.

About the author

Dr **Rodrigo B. Salvador** is a malacologist, that is, a researcher specialized in the study of mollusks. Given his fondness for land snails, most of his research centers on them. He was playing *Mario Wonder* despite the amount of unwarranted violence against the snail fauna the game contains, but put that on hold when *Persona 5 Tactica* was released.