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Pokécrustacea: the crustacean-inspired Pokémon

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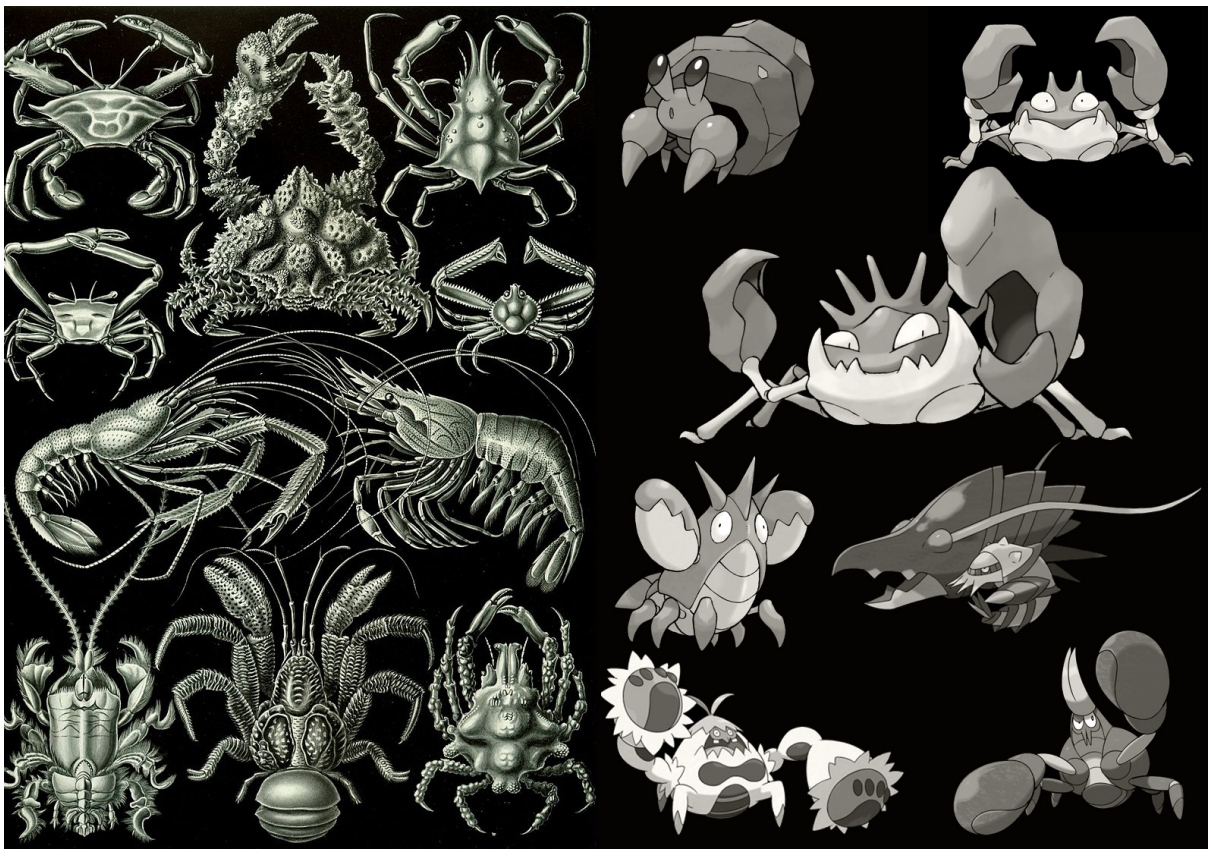
Crustaceans are a large and incredibly diverse group of very familiar animals such as crabs, lobsters, shrimps, woodlice, barnacles, and their allies. As full-fledged arthropods (invertebrate animals with an exoskeleton, a segmented body, and paired jointed appendages), they comprise over 70,000 species (Brusca et al., 2016) ranging in size from a fraction of a millimeter to respectable few meters of leg span (e.g., the Japanese spider crab can reach a whopping 3.8 m or 12.5 ft). They are quite an ancient group, ranging back to the Cambrian period some 511 million years ago. Some existing animals are virtually identical to fossilized forms from the Triassic, dating back 200 million years ago.



Left: Decapods, from German zoologist Ernst Haeckel's 1904 work "Kunstformen der Natur". Right: Pokémon inspired by real-world decapods.

Despite being classically identified as a group of their own, recent studies have shown that Crustacea is actually a paraphyletic taxon (that is, a group of animals that doesn't include all descendants of their common ancestor) and that some crustaceans are more closely related to Hexapoda (insects and their allies) than to other crustaceans (Regier et al., 2010; Lozano-Fernandez et al., 2019). Evolutionarily speaking, this means that insects are a strange group of air-breathing winged crustaceans (and that a Bug Type for a crustacean Pokémon is not biologically incorrect after all). Nonetheless, the traditional grouping of "classic" crustaceans, though now considered informal, is still used for practical purposes. Furthermore, the insect Pokémon have already been addressed by Kittel (2018).

Crustaceans are mostly aquatic or semi-aquatic, of course, with exceptions such as the terrestrial woodlice that are commonly found in gardens. Humans are known to feed on crustaceans quite intensely, which is one of the reasons why these animals are featured in several aspects of our culture from tapestry, paintings, sculptures, folklore and mythology (constellations even!) since time immemorial. More recently, though, crustaceans have been depicted quite often in movies and even electronic media, especially games. Much like the equally amazing mollusks (see Cavallari, 2015; Salvador & Cavallari, 2019), several games include crustaceans showing up as funny cameos, fierce adversaries (e.g., Final Fantasy series), and more rarely as some of the main stars.

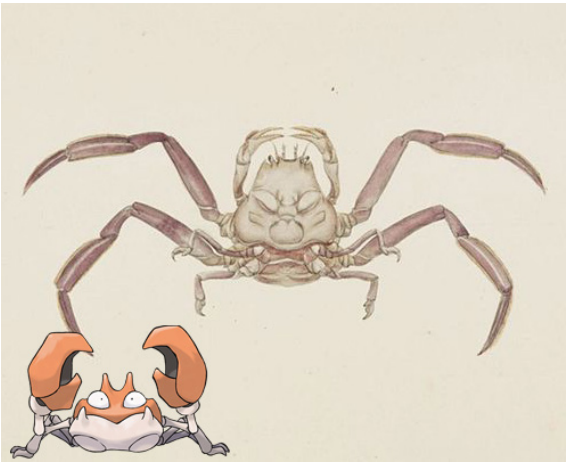
In the Pokémon franchise, crustaceans play an important role, having inspired some of the coolest monsters out there. The goal of this article is to present the crustacean-based Pokémon, discuss their real-world inspiration and explain a little bit about their biology. We outline specific features of the real animals that were transported to the games (such as types, moves, abilities, etc.) whenever possible.

"Crayfish and Two Shrimps", by Utagawa Hiroshige, 1835–1845.

LIST OF CRUSTACEAN POKEMON

Krabby

(#98; Type: Water)



Krabby (bottom left) and a drawing/watercolor illustration of the samurai crab, *Heikeopsis japonica* (von Siebold, 1824) from the Naturalis Biodiversity Center Art Collection (catalog number RMNH.ART.79).

Class: Malacostraca

Order: Decapoda

Infraorder: Brachyura

Family: Dorippidae or Dotillidae

Genus: *Heikeopsis* Ng, Guinot & Davie, 2008, *Dotilla* Stimpson, 1858, or *Scopimera* De Haan, 1833

Species: *Heikeopsis japonica* (von Siebold, 1824), *Dotilla* sp., or *Scopimera* sp.

Together with Kingler, Krabby is perhaps one of the most iconic crustacean Pokémon. Not only because of its resemblance to real-world crabs, which are arguably the most well-known crustaceans, but also because it was the only crustacean Pokémon for a long time in the franchise. This situation was changed only after the introduction of Corphish in Gen. III (#341, see below). Yes, to our chagrin, the *Pokémon* franchise had an entire generation without crustaceans.

Biologists classify crabs in the order Decapoda (from the Ancient Greek δἑκα, *déca*, 'ten' + ποὑς, *poús*, 'foot'), a major group that includes many familiar animals besides crabs, such as crayfish, crabs, lobsters, prawns, and shrimp. Decapods can have dozens of appendages arranged in one pair per body segment, ten of which, as the name implies, are considered legs. Within the Decapoda, the infraorder Brachyura (a New Latin name derived from the Ancient Greek: βραχύς, *brakhús*, 'short' + οὐρά, *ourá*, 'tail') contains the taxa (groups of organisms) known as the "true crabs". True crabs have a symmetrical but much reduced abdomen (technically known as pleon) that is usually flexed beneath the thorax (a.k.a. pereon), a dorso-ventrally flattened body protected by an expanded carapace (Brusca et al., 2016). They usually have characteristic well-developed claws. Most of these traits are present in Krabby's design (and Kingler's as well, see below) and leave no doubt about its "true crab" inspiration. However, Krabby's generic and stylized appearance makes it difficult to work out a real-world classification beyond that level.

Bulbapedia (2020) speculates that Krabby's design may be based on the samurai crab, *Heikeopsis japonica* (von Siebold, 1824). In our opinion, reaching this conclusion only from the generic design might be a stretch, but there are some interesting elements to consider. Most crabs we know have well-developed clawed appendages and four pairs of similarly-sized walking appendages or legs (a.k.a. pereiopods). Krabby only has two pairs of walking legs, which is quite unusual for crabs in general. But, interestingly, although samurai crabs have four pairs of legs, two of them are much reduced. This could have misled designers, or these two pairs of legs could have been omitted to avoid a messy design. Moreover, *H. japonica* specimens are often red and white much like Krabby, which is further evidence in favor of this hypothesis.

A sand bubbler crab (*Scopimera globosa*) and its sand bubbles. Photo by Dcubillas (CC-BY-3.0).

Still according to Bulbapedia, other real-world inspiration candidates for Krabby's design are the sand bubbler crabs. Those crabs belong to the genera *Dotilla* or *Scopimera*, and are named after the habit of feeding by filtering organic material (e.g., detritus and stranded plankton) present in the sand, leaving behind small balls made of the substrate. They are very common in the Indo-Pacific (including Japan), usually found on tropical and sub-tropical sheltered sandy beaches (Maitland, 1986). Indeed, a Pokédex statement seems to point in that direction: "If it is unable to find food, it will absorb nutrients by swallowing a mouthful of sand" (Gen. II, *Pokémon Crystal*). In any case, the matter is still inconclusive.

One last note: the way this Pokémon's eyes are drawn does not match the eyes of the crabs that probably inspired its design. Both samurai crabs and sand bubbler crabs have pedunculated eyes: that is, the eyes are on the distal end (tip) of eye-bearing appendages. In fact, Krabby's little "double horns" could actually be said appendages. The same partially applies to its evolved form, Kingler (the double horns are absent).

Kingler

(#99; Type: Water)

The red king crab, *Paralithodes camtschaticus* (photo by The Children's Museum of Indianapolis), and Kingler (bottom right).

Class: Malacostraca

Order: Decapoda

Infraorder: Brachyura and Anomura

In the *Pokémon* franchise, the design usually tends to highlight more aggressive features to provide evolved forms with a fiercer appearance. This is certainly true for Kingler, which evolves from the milder-looking Krabby. As in the previous stage, Kingler's identity as a decapod crustacean is quite clear. However, it is from there that things start to get messy.

Kingler's claws are disproportionate, one being much larger and more prominent than the other. This feature is seen in the real world animals known as fiddler crabs. In fact, Kingler's name seems to be an amalgam of the words "king" and "fiddler", according to Bulbapedia (2020). Nevertheless, much like Kingler, the oversized claw of fiddler crabs, which belong to the infraorder Brachyura (the true crabs, see Krabby above), is one of their most remarkable features. The Pokédex states that "Kingler has an enormous, oversized claw. It waves this huge claw in the air to communicate with others" (Gen. III, *Pokémon Ruby*). Real world fiddler crabs do communicate using a sequence of waves and gestures with their claws. In males, the larger claw is also used in courtship and copulatory disputes (Pope, 2000; How et al., 2008).

This brings us back to the matter of the aggressive appearance of the evolved forms: besides the malicious grin, Kingler presents a set of spikes that resemble a crown, hence its name. Well, actually, there is a group of particularly spiny crustaceans known as king crabs, a.k.a., the superfamily Lithodoidea. Unlike the brachyurans (see Krabby above), lithodoideans are not true crabs: they belong to the infraorder Anomura, the sister taxon (the closest relative) of Brachyura. Interestingly, those animals do have a body asymmetry, for example between their claws, which is supposedly due to a common ancestry with hermit crabs (Noever & Glenner, 2018). Therefore, it is highly likely that inspiration for Kingler's design was drawn from both fiddler crabs and king crabs.

Several iterations of the Pokédex highlight the "overwhelming power" of kingler's claws, offering 10,000 hp (horse power) as an exciting measurement of strength. This type of unit is generally not used to measure the gripping pressure of animal claws or bites; instead, the measurement is usually given in Newtons. Some of Kingler's attacks allude to his giant claw and its respective powerful grip: Hammer Arm, Metal Claw, Crabhammer, Guillotine, and X-Scissor. Nevertheless, the real-world crab with the most impressive gripping strength is the coconut crab (*Birgus latro*), which we will discuss below in Crabrawler's entry. We believe that this repeated allusion to the strength of Kingler's claws has more to do with its design, which exacerbates the difference in size between the claws, than something based on the biology of real-world crustaceans.

One last interesting detail: Kingler has a Gigantamax form, a new category introduced in Gen. VIII. The design seems to be loosely based on the Japanese spider crab, the largest living crustacean. Either way, the design tends to exaggerate shapes and

proportions, which prevents us from analyzing it further.

Corphish

(#341; Type: Water)

Procambarus clarkii taken near a lake in Gironde, France, photo by Duloup (CC BY 3.0) and Corphish (bottom right corner).

Class: Malacostraca

Order: Decapoda

Superfamily: Astacoidea

Family: Cambaridae

Genus: *Procambarus* Ortmann, 1905

Species: *Procambarus clarkii* (Girard, 1852)

Corphish, with its clawed appendages and flat tail, is clearly reminiscent of crayfishes and lobsters. These two crustaceans are closely related and share many similarities, such as bearing claws on the first pair of appendages, a tough carapace covering the head and thorax, and a tail fan at the end of the abdomen. Nonetheless, their ecologies differ considerably: lobsters are restricted to saltwater environments, as opposed to the exclusively freshwater crayfishes. Furthermore, one can tell them apart from their general body proportions, as lobsters tend to be bigger and much longer than crayfishes. Corphish is usually found in lakes, which seems to indicate it is a crayfish. Additionally, Bulbapedia (2020) suggests that the name Corphish might be derived from the word "crayfish" itself. Although Corphish's design is quite generic and lacks the characteristics needed to identify its species, there is some interesting information that can help us pinpoint this Pokémon's real-world inspiration.

According to Pokédex, Corphishes were "originally foreign Pokémon that were imported as pets", and "individuals that have been set free by Trainers who could no longer raise them have become common, and they can now be found in Alola". In other words, Corphish is an exotic species introduced to Alola, which is the equivalent of Hawaii in the *Pokémon* world. While some introduced species can have neutral or even positive impacts, most are often a problem to local ecosystems. The worst offenders are the so-called invasive species. They spread fast, have few or no natural predators at the invaded areas and quickly outcompete the local species, causing varying degrees of damage to the environment. Most readers will probably be familiar with some invasive species (in fact, one could argue that humans themselves are one of the world's most successful invasive species out there). Some examples include the house sparrow (*Passer domesticus*), the giant African land snail (*Achatina fulica*) and the congograss (*Imperata cylindrica*), all very widespread outside their original range. If you live on an island, this problem might be even more evident. Insular ecosystems tend to host a myriad of unique species that evolved in isolation from the continent for millions of years and are not prepared to compete with their alien cousins. Corphish shows signs of being a potential invasive species. Present and past iterations of the Pokédex state that "no matter how dirty the water in the river, it will adapt and thrive" (Gen. VIII, *Pokémon Sword*) and that "this Pokémon is very hardy and has greatly increased its population" (Gen. III, *Pokémon Ruby*). Its biological resilience indicates that Corphish can — and likely will — outcompete any endemic crayfish Pokémon in invaded areas.

Curiously, there is a famous case of an invasive crayfish with the same profile: *Procambarus clarkii*, the red swamp crayfish. *Procambarus clarkii* is native to southern USA and northern Mexico, but has been widely introduced to many continents and islands, including Hawaii. Able to breed fast and tolerate environmental conditions that would be hostile to most crayfishes (e.g. low levels of dissolved oxygen or moderate salinity), *P. clarkii* is considered one of the most resilient crustaceans. Following its introductions, *P. clarkii* has changed entire ecosystems, removing water plants through grazing (and thus allowing the proliferation of phytoplankton), preying on native invertebrates, fishes and tadpoles, and even carrying diseases that are lethal to other species of crayfish (Loureiro et al., 2015).

Therefore, it seems that Corphish is the *Procambarus clarkii* of the Pokémon world and, as such, we can only hope it is less noxious to Alola's ecosystem than its real-world counterpart is to invaded areas.

Crawdaunt

(#342; Type: Water)

Crawdaunt.

Class: Malacostraca

Order: Decapoda

Superfamily: Astacoidea

Crawdaunt is yet another example of the trend to provide evolved forms with aggressive features and a more ferocious overall appearance: the spikes on the claws and legs are an undeniable testament to this intention. In the specific case of Crawdaunt, the temperament is also more aggressive, as the Pokédex reiterates for several generations, mentioning its "extremely violent nature" (Gen. III, *Pokémon Ruby*), or flat out stating that it is "a brutish Pokémon that loves to battle" (Gen. III, *Pokémon Emerald*) and even "a ruffian that uses its pincers to pick up and toss out other Pokémon from its pond" (Gens. IV to VI, several games). Those statements may be a nod to the competitive behavior of *P. clarkii* as an invasive species (see Corphish, above). Anyway, as unfortunately sometimes happens, the more stylized design of the evolved form prevents further conclusions on the biological classification of this Pokémon, though one could assume it is also inspired on *P. clarkii* based on its behavior.

Interestingly enough, the Pokédex highlights the fact that Crawdaunt "molts [sheds] its shell regularly. Immediately after molting, its shell is soft and tender. Until the shell hardens, this Pokémon hides in its streambed burrow to avoid attack from its foes" (Gen. III, *Pokémon Sapphire*, and Gen. VI, *Pokémon Alpha Sapphire*). This exoskeleton-shedding process is very real, and is known technically as ecdysis. It actually occurs in a huge group of animals known as Ecdysozoa, which includes arthropods and other groups (Telford et al., 2008).

Dwebble

(#557; Type: Bug / Rock)

Dwebble (top left), and the hermit crab *Cancellus typus* (photo by Michael Marmach, Victoria Museum (CC BY 4.0).

Class: Malacostraca

Order: Decapoda

Family: Diogenidae

Genus: *Cancellus* H. Milne Edwards, 1836

It takes no biology major to notice that Dwebble's design was based on hermit crabs. These charismatic crustaceans are known and loved by many, with some species being commonly kept as pets. There are approximately 1,110 known species of hermit crabs, all belonging to the clade Paguroidea. Most hermit crabs are marine, but there is at least one species known to live entirely in freshwater (*Clibanarius fonticola*) and 17 land-dwelling species. The terrestrial hermit crabs belong to the family Coenobitidae, which includes the titanic *Birgus latro*, or coconut crab, the largest terrestrial invertebrate of all (see Crabrawler below).

More than anything else, hermit crabs are known for their peculiar use of molluscan shells. Unlike other crustaceans, these crabs have soft abdomens that lack the tough exoskeleton found on the rest of the body. Of course, such a vulnerability would not go unnoticed by the ruthless workings of natural selection — and this is where the shells come in. These ingenious crabs scavenge shells left by dead mollusks and wear them as a mobile shelter or body armor to protect their soft parts. While they seem to prefer shells that are already empty, a desperate crab might even kill a mollusk to steal its shell in times of shortage. The most common targets seem to be snail shells, but there are species known to wear shells of bivalves and scaphopods, while others might even use corals or hard tubes secreted by annelids. In fact, hermit crabs are so well adapted to wear snail shells that most of them even have a coiled and asymmetrical abdomen, which is perfectly fit for holding on to the shell's columella or axis.

So that brings us back to Dwebble. While it is clearly a hermit crab, a careful eye might have noticed that this Pokémon does not wear a shell, but a rock. Dwebble's seemingly unique behavior has been discussed in Salvador & Cavallari (2019), where it is tentatively associated with hermit crabs known to wear fossilized shells or corals instead of regular shells. Nonetheless, we propose a different take on Dwebble's biology: the answer might be on a rather obscure, yet very interesting, genus of hermit crabs.

Ladies and gentlemen, we present you *Cancellus*. With 16 recognized species, *Cancellus* is distinctive among hermit crabs for a series of reasons, such as having a mostly symmetrical and uncoiled abdomen. Most interesting, however, is the fact that *Cancellus* crabs are known not to wear molluscan shells. Some species substitute the shells for siliceous sponges, calcareous algae, dead corals or annelid tubes, but most seem to prefer sedimentary or volcanic rocks (McLaughlin, 2008). Much like our little friend Dwebble, *Cancellus* carries its rocky shelter for protection and can fit its entire body inside a cylindrical cavity on it. Pokédex states that Dwebble makes its own hole, with aid of a liquid secreted from its mouth, but we currently don't know how *Cancellus* digs the cavity on its rock, or whether it is dug by them at all (Mayo, 1973).

There is one problem with this analogy though: Dwebble is terrestrial. All known species of *Cancellus* are marine, much like your regular hermit crab. In fact, they are

not even closely related to the terrestrial Coenobitidae. Then how can Dwebble be both terrestrial, like coenobitids, and carry a rock, like *Cancellus*?

One could argue that Dwebble is actually a coenobitid that started to use rocks independently from *Cancellus*, being a curious case of convergent evolution. This hypothesis is not supported by morphology though, seeing that Dwebble's body is symmetrical and uncoiled, much like *Cancellus* and unlike any species of Coenobitidae. Thus, we suggest an alternative hypothesis: Dwebble is, actually, a species of *Cancellus* that independently acquired a terrestrial lifestyle. An independent transition from water to land would not be unheard of, considering that arthropods (which includes crustaceans) are notorious for having invaded land at least seven times in separate lineages during their evolution (Dunlop et al., 2013).

So, could Dwebble be inspired by a little-known genus of stone-bearing hermit crabs? More than that, could it be considered a new species within that genus (*Cancellus dwebblei*, anyone?), independently forsaking its water-bound past in order to become the terrestrial crab we all know and love? Unlikely, but an amusing thought regardless.

Crustle

(#558; Type: Bug, Rock)

Crustle.

Class: Malacostraca

Order: Decapoda

Family: Diogenidae

Genus: *Cancellus* H. Milne Edwards, 1836

Crustle is very similar to Dwebble. It only seems to be the tough grown-up version (as usual) of our cute little hermit crab. In any case, most of the observations about Dwebble also apply to Crustle.

Binacle

(#688; Type: Rock / Water)

The Japanese goose barnacle, *Capitulum mitella* (photo by Daiju Azuma, CC BY SA 2.5), and Binacle (top right corner).

Class: Hexanauplia

Infraclass: Cirripedia

Superorder: Thoracica

Order: Scalpelliformes

Family: Pollicipedidae

Genus: *Capitulum* Gray, 1825

Species: *Capitulum mitella* (Linnaeus, 1758)

Most people might figure out that Binacle resembles a pair of goose barnacles, but what most people might forget is that barnacles are crustaceans. However, they are only distantly related to crabs and lobsters. While most of the well-known crustaceans are part of the clade Malacostraca, barnacles and their closest relatives belong to another clade, named Hexanauplia, along with the microscopic copepods (e.g., *SpongeBob's* Plankton).

The history of barnacle zoology, aptly named Cirripedology, is quite interesting in itself. These strange animals were once regarded as mollusks by classic taxonomists, such as Linnaeus and Cuvier, before being properly recognized as crustaceans. Later on, barnacle taxonomy was subject to the studies of the great Charles Darwin himself. Darwin's contributions to cirripedology are still regarded as of great importance, though Charles didn't seem to be so fond of them by the end of his work. In his own words, he stated: "I am at work on the second vol. of the Cirripedia, of which creatures I am wonderfully tired: I hate a Barnacle as no man ever did before, not even a Sailor in a slow-sailing ship" (Darwin Correspondence Project, 2020).

Goose barnacles, like Binacle, are distinguished by being adhered onto rocks and other hard substrates (e.g., a ship's hull, whales, sea turtles) through a flexible stalk or peduncle. Once adhered, the barnacle's body lies upside down, with the "tentacles" (or "fingers", in Binacle's case) actually being its legs. As if that wasn't weird enough, the soft parts of these odd crustaceans are completely encased within a hardened structure made of calcareous plates, which roughly correspond to other crustaceans' carapaces. Oh yeah, and they are also heartless (Brusca et al., 2016).

According to the Pokédex, two Binacle share a rock and cooperate for survival. In other words, this Pokémon lives in colonies, like real barnacles. These assemblages are a common sight in rocky shores, where large groups of barnacles live closely together in the intertidal rocks. Since the intertidal zone is limited and everyone wants their place in the sun, competition for space often becomes a problem. The most common contenders include other barnacles and mollusks such as mussels and limpets. As a result, it is not uncommon to find a great biodiversity of sessile invertebrates crowded together and constantly attempting to displace each other in these environments.

Binacle's Japanese name, *Kametete* (カメテテ), suggests that it was likely inspired by the species *Capitulum mitella*, a.k.a. the Japanese goose barnacle or *kamenote* (カメノテ) (Bulbapedia, 2020). In fact, Binacle's design shows a vague resemblance to *C. mitella*, but it is far too generic (and anatomically incorrect) to fuel a more in-depth discussion.

Barbaracle

(#689; Type: Rock, Water)

Barbaracle.

Class: Hexanauplia

Infraclass: Cirripedia

Superorder: Thoracica

Order: Scalpelliformes

Family: Pollicipedidae

Genus: *Capitulum* Gray, 1825

Species: *Capitulum mitella* (Linnaeus, 1758)

Not Barnacle Boy (from the show SpongeBob), but Barbaracle looks like an anthropomorphic barnacle. Again, this is a colonial Pokémon, formed once two Binacle multiply into seven through evolution. Unlike Binacle, however, the barnacles on Barbaracle seem to be fused and act as a single organism (despite having "minds of their own", according to the Pokédex). This is not unheard of in zoology, since colonial organisms like this are common in many taxa, such as bryozoans and corals. In such cases, individuals within a colony, known as zooids, are anatomically attached to each other. Some zooids can have specific functions within a colony (e.g., feeding zooids, defense zooids, reproductive zooids), which seems to be the case with Barbaracle's arm and leg "zooids".

Nonetheless, while real barnacles do live in colonies, they are not colonial organisms in this sense. Each barnacle in an assemblage is still very much an independent organism and not linked to its conspecifics in any way. Essentially, it's every barnacle for itself out there. It's unclear whether Barbaracle is a full-fledged colonial organism or just a particularly cooperative assemblage of barnacles, but it seems to lean towards the former. Anyway, aside from this oddity, Barbaracle is very similar to Binacle in most aspects. It was probably inspired by *Capitulum mitella* as well, since its Japanese name (*Gamenodes*, ガメノデス) also stems from the word *kamenote*.

Clauncher

(#692; Type: Water)

Clauncher (top left) and the pistol shrimp *Alpheus eulimene* (photo by Moorea Biocode, CC BY NC 3.0).

Class: Malacostraca

Order: Decapoda

Infraorder: Caridea

Superfamily: Alpheoidea

Family: Alpheidae

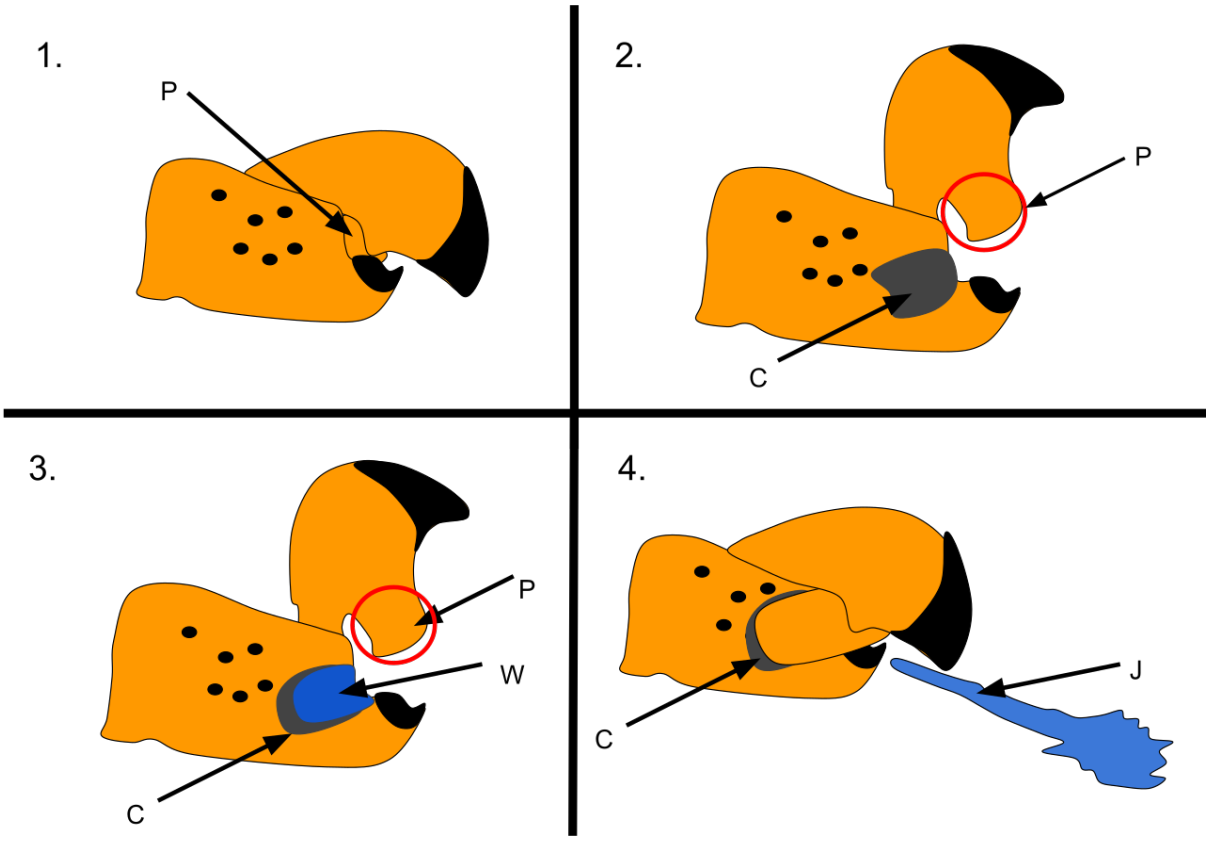
Genus: *Alpheus* Fabricius, 1798

Species: *Alpheus eulimene* De Man, 1909

Clauncher's design is probably based on *Alpheus eulimene*, a blue-and-yellow shrimp species with black stripes that is widely distributed in the Pacific, including Japan (Sha et al., 2019). It belongs to the very pe-

culiar family Alpheidae, a.k.a. the snapping shrimps or pistol shrimps. Pistol shrimps are known for their characteristic asymmetrical claws, the larger of which can be used to produce an incredibly loud snap. In fact, a pistol shrimp's snapping sound can reach up to 210 decibels (Versluis et al., 2000), which is even louder than an actual gunshot (around 150 decibels). Despite being just a few inches long (3–5 cm or 1.2–2.0 in), pistol shrimps are so noisy they compete with gigantic sperm whales and belugas for the title of the loudest animals in the ocean!

And it's not all about noise: by snapping its claw shut, a pistol shrimp produces a highly pressurized and very fast jet stream. The water is forced to move so fast it evaporates producing a small vapor-filled cavity known as a cavitation bubble, which travels at breakneck speed along a short distance (ca. 4 cm). By using the trail the bubble leaves behind, the average speed of the water jet can also be estimated at 90 km/h (Versluis et al., 2000). If that weren't enough, when the cavitation bubble collapses, it releases a massive amount of energy and produces a huge amount of heat, reaching temperatures of over 5,000 K or 4,700 °C (Lohse et al., 2001), which is close enough to the temperature of the sun's surface (circa 5,800 K or 5,500 °C)! Of course, all this heat is generated on a very small scale, but that doesn't make this virtual underwater hadouken any less awesome (or proportionally powerful). Oh, and did we mention that this phenomenon also produces light? Light generated this way is actually a very exclusive kind of bioluminescence, a.k.a. the production and emission of light by a living organism, that only pistol shrimps can pull off (see Lohse et al., 2001).



A real-world pistol shrimp's snap at work. 1. Closed pistol shrimp claw with slightly hidden plunger (P). 2. Open claw with exposed plunger (P) and socket (C). 3. Open claw with water (W) entering the socket (C). 4. Closed claw with plunger (P) pushed into the socket (C), forcing a jet stream (J) out. Diagram by Carvermyers (CC BY SA 4.0).

Still regarding the snap itself, one might wonder what it is used for. Real-world pistol shrimps use it to communicate among themselves through sound. However, it can also be used as a weapon, since the resulting shockwave is powerful enough to stun or even kill small prey (Versluis et al., 2000). So Clauncher's Water Gun and Bubble attacks both probably allude to that unusual and powerful hunting strategy. The Pokédex even supports this idea by stating that "they knock down flying prey by firing compressed water from their massive claws like shooting a pistol" (Gen. VI, *Pokémon X*), and even more directly states that "by detonating gas that accumulates in its right claw, this Pokémon launches water like a bullet. This is how Clauncher defeats its enemies" (Gen VIII, *Pokémon Shield*).

On its account on Clauncher in *Pokémon Ultra Sun* (Gen. VII), the Pokédex states that "[its] claws occasionally fall off, and it keeps a low profile until they grow back". Well, this is actually kind of true for real-world pistol shrimps. They can regenerate claws that have been torn off, but instead of "keeping a low profile" while it grows back, they actually transform the remaining regular claw into a snapping one. This in turn inhibits the newly regenerating claw from transforming into a snapping claw too. Thus, eventually, a pistol shrimp's pistol can switch sides, which makes them harder to disarm (Read & Govind, 1997).

Clawitzer

(#693; Type: Water)

Clawitzer.

Class: Malacostraca

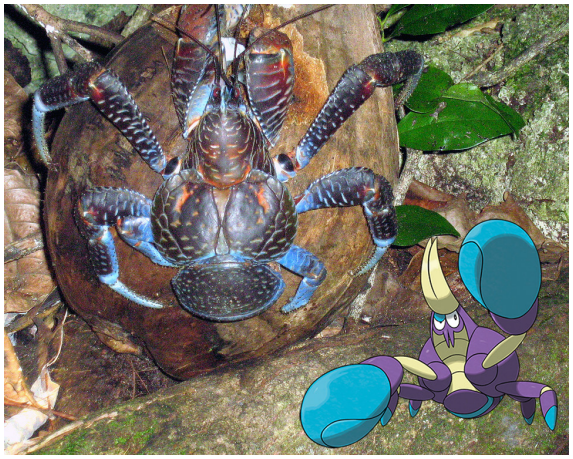
Order: Decapoda

Family: Alpheidae

Clawitzer's design maintains the pistol shrimp-themed appearance like Clauncher, though it is much more stylized. As usual in the evolved forms (see comments in Kingler's entry above), it has exaggerated traits and a more aggressive semblance. Its name is an amalgam of two words, "claw" (an obvious reference) and "Howitzer", a type of cannon-like artillery piece, alluding to Clawitzer's cannon-like right claw. To complete the more ferocious appearance, the main claw appears to have been designed to look like the head of a large beast, possibly a wolf or even more likely, a dragon, as Clawitzer has a dragon-themed attack (Dragon Pulse). In any case, most of the observations about Clauncher also apply to Clawitzer, but due to the stylized design, any classification beyond family level would be a stretch.

Crabrawler

(#739; Type: Fighting)



The coconut crab, *Birgus latro* (photo by fearlessRich, CC BY 2.0), and Crabrawler (bottom right).

Class: Malacostraca

Order: Decapoda

Family: Coenobitidae

Genus: *Birgus* Leach, 1816

Species: *Birgus latro* (Linnaeus, 1767)

With powerful pincers and a tendency to pick fights, Crabrawler is the boxer of Pokécrustaceans. This heavyweight fighter is inspired by an equally powerful and heavy crustacean: *Birgus latro*, a.k.a. the coconut crab, robber crab or palm thief. As we've mentioned before, the coconut crab is the largest terrestrial invertebrate in modern times. The largest individuals can weigh up to 4 kg and measure 1 m in width (including the legs), which is a gargantuan size when compared to the heaviest recorded insect (a giant weta) at 71 g. As a side note, the title of largest land arthropod of all time still goes to the giant *Arthropleura* millipedes of the Late Carboniferous, which could grow up to 2.5 m long and probably weigh several kilograms.

Interestingly, *Birgus latro* is a hermit crab and the young ones are even known to carry gastropod shells. By contrast, the adults are too big to fit inside any available shell and compensate for this vulnerability by hardening the exoskeleton in their abdomens during growth. Like all hermit crabs, *B. latro* belongs to the clade Paguroidea, which means that Crabrawler is closely related to Dwebble and Crustle (and possibly Kingler, if it is indeed a king crab). Unlike those Pokémon, however, coconut crabs are part of the family Coenobitidae, along with the other land-dwelling hermit crabs (except Dwebble and Crustle, as discussed in the former's entry).

As mentioned earlier in Kingler's entry, the coconut crab has the strongest grip of all crustaceans. Their pinching force has been recorded to reach striking 1,765 N (newtons), but some estimates suggest that larger individuals might even reach up to 3,300 N. Not only is this stronger than the pinching force of all other crustaceans, but it's also stronger than the bite forces of most terrestrial predators. On top of that, coconut crabs are also capable of lifting weights many times heavier than themselves, with some individuals reported to lift up to 28 kg (Oka et al., 2016). With that in mind, it comes as no surprise that Crabrawler's moves include Hyper Cutter and Iron Fist.

Despite its weight, the coconut crab is also an excellent climber. Their legs are particularly long and muscular, capable of bearing the crab's weight in nearly vertical climbs. Those crabs are often observed climbing coconut trees in their natural habitat, which seems to be mostly a way to escape predators. Interestingly, the Pokédex states that "Crabrawler has been known to mistake Exeggutor for a coconut tree and climb it", though we doubt that this fierce Pokémon would try to flee from an adversary rather than fight it.

What kind of predator could eat these crabs though? Other coconut crabs, of course! These animals are omnivorous and their diet consists mostly of fruits, seeds and occasionally carrion, but coconut crabs are known to prey upon other crabs (including their own kin), rats and even large birds (Wilde et al., 2004; Kessler, 2005; Laidre, 2017). Coconut crabs are also consumed by humans, but their flesh might be toxic de-

pending on the crab's diet (Mailaud et al., 2010). This does not seem to be the case for Crabrawler though, as the Pokédex states that the meat on their pincers, while scarce, is "rich and delicious."

Crabominable

(#740; Type: Fighting / Ice)

The yeti crab, *Kiwa hirsuta* (photo by Andrew Thurber, CC BY SA 2.0), and Crabominable (bottom right corner).

Class: Malacostraca

Order: Decapoda

Family: Kiwaidae

Genus: *Kiwa* Macpherson, Jones & Segonzac, 2006

Species: *Kiwa hirsuta* Macpherson, Jones & Segonzac, 2006

Crabrawler's evolved form is noteworthy because, unlike the ones discussed earlier, it looks like a completely different animal. In fact, it looks like two completely different animals, since Crabominable's design shows a strange mix of mammalian and crustacean features. It is clearly a crab, with paired articulated appendages, a compact body and an abdomen folded beneath its body. However, it also has white fur, paw-like pincers, a mouth with teeth and a tongue, and a thorax very reminiscent of gorillas. As its name suggests, Crabominable's mammalian aspects are inspired by the legendary Yeti, or Abominable Snowman, a folkloric ape said to inhabit the tall mountains of the Himalayas. Most descriptions of the Yeti make no mentions of crustaceans though, with the notable exception of the Cthulhu Mythos' Mi-Go (crustacean-like eldritch horrors that are said to be the in-universe inspiration for the Yeti legends).

There is, however, one species of crustacean that has been dubbed the "Yeti crab": *Kiwa hirsuta*. It is unique in having appendages densely covered by long, hair-like setae, granting those crabs a rather furry appearance. *Kiwa hirsuta* is a deep sea species, inhabiting hydrothermal vents in the South Pacific Ocean, where it likely feeds on bacteria and meat. Nonetheless, despite being likely inspired by this crab, the similarities between Crabominable and its real-world counterpart are little more than the white fur-like integument and the association with the Yeti. Unlike *K. hirsuta*, Crabominable is fully terrestrial, lives at the alpine tundra of high mountains and has a much more compact body (not to mention its clearly gorilla-inspired features).

Interestingly, the Pokédex mentions that this Pokémon "got lost and ended up on a snowy mountain", where it "evolved and grew fur" in response to the cold environment. This could indicate that Crabominable belongs to a new species altogether, perhaps not even related to the *Kiwa* genus at all. How would a lost crab evolve into an ape-crab hybrid with ice powers remains a mystery, but, then again, evolution in the Pokémon franchise does not work like biological evolution at all.

Wimpod

(#767; Type: Bug, Water)

A sea slater (*Ligia* sp.; photo by me'nthedogs, CC BY 2.0) and Wimpod (upper right corner).

Class: Malacostraca

Order: Isopoda

Unlike the other Pokémon discussed so far, Wimpod is not based on crabs or shrimps, nor is it a barnacle. The design of this Pokémon is based on a relatively less familiar type of crustacean belonging to the Order Isopoda. It includes the sea slaters, pillbugs, roly-polies, and their allies. The name Isopoda is New Latin, derived from Ancient Greek ἴσος (*ísos*, 'equal') and πούς (*poús*, 'foot'), alluding to its numerous similarly-sized paired legs. They are a huge 300-million-years-old group including over 10,000 species distributed worldwide in marine, freshwater and terrestrial environments.

Golisopod

(#768; Type: Bug / Water)

The giant isopod, *Bathynomus* (photo by Emily Osterloff, Natural History Museum, London), inspired the design of Golisopod (top left).

Class: Malacostraca

Order: Isopoda

Suborder: Flabellifera

Family: Cirolanidae

Genus: *Bathynomus* A. Milne-Edwards, 1879

Judging by its name (an amalgam of 'goliath' + 'isopod'), the numerous paired appendages and articulated heavy armor (or exoskeleton), Golisopod's design is most likely based on a group of impressive deep-sea dwellers: species in the genus *Bathynomus*, commonly known as the giant isopods. Distant relatives of shrimps and crabs, giant isopods are closely related to woodlice, which are quite small (a few millimeters to 5 cm), but are many times as large. Some species (*Bathynomus giganteus*, for instance) attain a typical length of about 30 cm, with the largest recorded specimen reaching a whopping 50 cm or nearly 20 inches (McClain et al., 2015).

DISCUSSION

As stated by Aristotle, art imitates life, and Pokémon designs make it clear. We can see that these creatures are inspired by real animals or combinations of different animals. Some of them look tougher than real life crustaceans, or show fewer legs, which is understandable when you consider all those legs would need to be animated. The similarities are not only related to their looks, but also to their attacks, distribution and habitats they occupy: Clauncher and Clawitzer, for instance, borrow their attack patterns and cool in-game facts from the extraordinary biology of pistol shrimps. Even real-world biological problems are addressed indirectly, e.g., Corphish and Crawdaunt, which reflect real-world biological invasions and the behavior of invasive species in a very interesting way. As biologists we'd love to see development team use their games as a means to draw attention to such problems, and the developers behind *Pokémon* has been doing that very gracefully (see the iconic case of Corsola in Salvador, 2019).

Although real phylogenetic (evolutionary) relationships don't seem to be valid among Pokémon, the combinations of different taxa give us the opportunity to imagine different paths real-world evolution could have taken. Fortunately, the crustacean Pokémon encompass several families of real crustaceans and reflect the great diversity of this group, though this is not often the case in the franchise (see Prado & Almeida, 2016, for an analysis on the arthropod diversity of Pokémon). We hope that other relevant groups of animals receive similar affection and attention: after all, Pokémon could very well ignite the spark of interest in the amazing biodiversity that surrounds us, especially for the younger generations.

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Daniel Cavallari is a zoologist and taxonomist who loves invertebrates, especially mollusks. He has been playing *Pokémon* since he was a kid, and does not intend to stop anytime soon.

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