On the Transatlantic Migration of *Cocos nucifera*

Yes, I am suggesting coconuts migrate

By Prerak Pokhrel

Preface

In 'Monty Python and the Holy Grail', a guard asks King Arthur the following question: "Are you suggesting coconuts migrate?" In the movie, King Arthur states that a swallow could carry a coconut while migrating back from the tropics, leading to a discussion on swallows. But I'm not here to calculate the airspeed velocity of an unladen swallow[1] as that's been done to death. Instead, I shall present to you how a coconut could migrate to the UK with nothing but natural causes. For the purposes of this essay, animal intervention will not be considered.

Clarifications

1. Our coconut will start in Senegal as it is in a torrid zone in Africa, thus allowing us to show the guard that the non-migratory nature of African swallows does not affect the migration of coconuts.
2. Its end goal is to reach the UK to prove that King Arthur could have feasibly acquired a coconut.
3. We will try and find a way for the coconut to migrate back to Senegal as Swallows don't migrate and stay away forever.
4. The condition of the coconut during this process doesn't matter. As long as it reaches the necessary locations, its migration will be successful.

The path

Our coconut's best hope is to follow oceanic currents. So, our coconut will begin by dropping into the Senegal River and flowing out into the North Atlantic Ocean. Here, it will ride the waves like an off-brand Moses, following the North Equatorial Current to the Americas where it goes along the Gulf Stream. In case it follows the Guinea Current instead, it can go along the South Atlantic Equatorial Current until it reaches the Guinea Current where, after taking a tour of the Caribbean Archipelago and the Gulf of Mexico, it'll merge with the Gulf Stream again. From here, the North Atlantic current will take it through the Celtic and into the Irish Sea.

[1] It's approximately 32.4 km/h for a European and 64.7 km/h for an African one. Still not enough to carry a coconut.

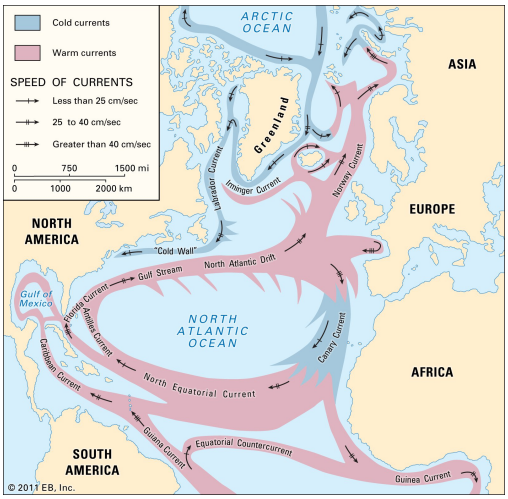

Figure 1 Ocean Currents in the North Atlantic Ocean

Now, proving that King Arthur could have picked up the coconut is trivial. Our coconut passes by Tintagel Castle, widely regarded as where King Arthur was born. It is very well possible that the King saw the strange hairy ball near his birthplace and picked it up, assuming it to be a blessing from the Lord. If the coconut didn't get reused for horse galloping, our coconut's best route home would be the Norwegian Current which goes up to the Arctic Ocean. In the Arctic Ocean, it would finally reach currents that turn back to the equator. The West Spitsbergen Current leads to the East Greenland Current, which again takes the coconut to the Labrador Current. This current meets the North Atlantic Current once again, which would take the coconut to the Azores Current. This current leads to the Portugal Current which *finally* reaches the Canary Current.

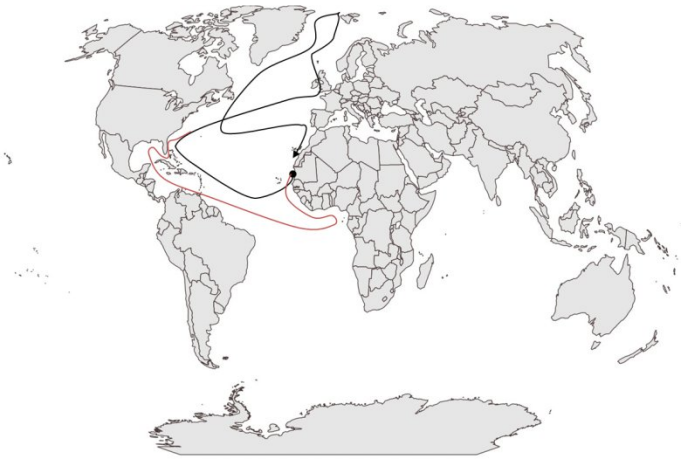

Figure 2 Path of the Coconut in Black, Diverged path in Red

Now, this entire path could be described in nine words (The North Atlantic Gyre and North Atlantic Subpolar Gyre) but I have a word count to reach on this essay.[2]

[2] What do you mean "There's no minimum word count"?

The Maths

We have our path. Now all we need is the maths. All the values that'll be necessary for this have been tabulated below (Note that all values are approximations since Ocean currents are dynamic):

Current	Length (l)	Average speed (s)
North Equatorial	5000 km (Senegal-Barbados)	0.72 km/h
Gulf Stream	4000 km (Barbados-St. John's)	9 km/h
North Atlantic	3500 km (St. John's-Brest)	3.7 km/h
Celtic and Irish Sea	1500 km (Brest-Bideford-Faroe Islands)	2 km/h (note[3])
Norwegian	2000 km (Faroe Islands-Svalbard)	1.08 km/h
West Spitsbergen	1500 km (Svalbard-Ittoqqortoormiit)	1.26 km/h
East Greenland	1500 km (Ittoqqortoormiit-Narsarsuaq)	0.324 km/h
Labrador	1500 km (Narsarsuaq-Labrador-St. Johns)	0.72 km/h
Canary	3000 km (Portugal-Senegal)	1.4 km/h

Distance travelled

The total distance travelled is just the sum of the distances of all these currents. Assuming the total distance is 'D',

$$D = l_{n.\ equatorial} + l_{gulf} + 2l_{n.atlantic} + l_{c.i.sea} + l_{norwegian} + l_{w.spitsbergen} + l_{e,greenland} + l_{labrador} + l_{canary}$$

Calculating D, we get 27,000 km. For reference, that's more than the distance Marco Polo travelled from Venice to China and back (24,000 km). It's also over half the circumference of the world (40,075 km.)

Time taken

Once again, we can just sum the time it would take for the coconut to traverse all these currents, which is just $\frac{l}{s}$ for each. So, assuming the total time to finish this journey is 'T',

$$T = \frac{l_{n.\ equatorial}}{s_{n.\ equatorial}} + \frac{l_{gulf}}{s_{gulf}} + \frac{2l_{n.atlantic}}{s_{n.atlantic}} + \frac{l_{c.i.sea}}{s_{c.i.sea}} + \frac{l_{norwegian}}{s_{norwegian}} + \frac{l_{w.spitsbergen}}{s_{w.spitsbergen}} + \frac{l_{e,greenland}}{s_{e,greenland}} + \frac{l_{labrador}}{s_{labrador}} + \frac{l_{canary}}{s_{canary}}$$

Substituting the values, we learn the time the coconut takes is approximately 20982.98 hours, 875 days or 2.4 years. This does not include the time our coconut spent stuck in eddies, on shores, etc. If we account for this by multiplying by 2.5, that's approximately six years. This is still one year less than the time Marco Polo took during his travel (ignoring his fourteen years of staying in China)

No. of Crew members

You may think that our coconut was completely alone on its journey, but you would be gravely mistaken. Why? Barnacles. Our coconut would have picked up many barnacles along its journey. Let's

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[3] This is an average of several different speeds around this area. Also, I formatted this footnote like this since 2^3 reads as 2^3 and km/h^3 reads as "Kilometer per cubic hour" and I don't like dealing with three temporal dimensions

calculate the zenith number of barnacles present. The radius of the average coconut (which we assume is 'R') is 10 cm with the husk and, assuming the barnacles gotten in the tropics are pelagic gooseneck barnacles (*Lepas anatifera*), the radius of the base 'r' of the peduncle is roughly 3 cm. So, we can calculate the number of crew 'N' by first finding the surface area of the coconut and dividing it by the area of the base of a barnacle's peduncle. Let the surface area of the coconut be 'A' and the area of the base of the barnacles be 'a'. Then,

$$A = 4\pi R^2 = 4 \times \pi \times 10^2 = 400\pi \text{ sq. cm}$$

$$a = \pi r^2 = \pi \times 3^2 = 9\pi \text{ sq. cm}$$

$$N = \frac{A}{a} = \frac{400\pi}{9\pi} = 44.\bar{4}$$

So, our coconut could have 44 barnacles on it, leading to a crew of 45 (counting the coconut itself). Marco Polo's crew when returning from China had roughly 2000 members, so he wins this round.

Crew mortality rate

Both our travelers had mass casualties during their travels. Marco Polo ended his travel to Persia with just 18 people left. Similarly, our coconut has only itself alive by the end of its journey as the barnacles would die in the arctic waters. But let's see who lost a larger proportion of their crew, assuming the lost percentage is 'L', initial crew is 'i' and final crew count is 'f'. Then the formula is

$$L = \frac{i - f}{i}\%$$

For the coconut,

$$L_{coconut} = \frac{45 - 1}{45}\% = 97.\bar{7}\%$$

For Polo,

$$L_{m.polo} = \frac{2000 - 18}{2000}\% = 99.1\%$$

As we can clearly see, the coconut wins as it lost a smaller proportion of its crew.

Calories consumed

During his travels, Marco Polo consumed a lot of food. The coconut, on the other hand, *is* the food.

Let's assume that Marco ate roughly 4500 calories each day. This number is obviously an estimate as 13th century explorers didn't track their caloric intake[4]. With him spending 7 years travelling (we won't include his 17 years in Kublai Khan's court to even the playing field) he would have consumed about $4500 \times 7 \times 365 = 11497500$ calories like the glutton he is. Our coconut, on the other hand, has about

[4] How rude. Clearly he should have used Nutracheck[4.5].

[4.5] What do you mean "That didn't exist in the 13th century"?

1500 calories to give, making its intake -1500 calories. Overall, Polo ate 766600% more calories than our coconut, so our coconut wins.[5]

Greenhouse gas emissions

If you think "This category will be a draw since Polo didn't use vehicles like modern times and a coconut is a coconut." then you're wrong. If you think "The coconut wins since the coconut tree absorbed CO_2 gas, leading to a negative number of emissions which is less than zero." then you're partially correct. If you think "Are you suggesting horses produce greenhouse gases?!" then you're correct.

Horses, believe it or not, produce a greenhouse gas: Methane (CH_4). Approximately 20 kg of the stuff each year, actually. Over four years, Marco would have released 80 kg of methane. This is equivalent to releasing 2240 kg of CO_2 as the GWP (Global Warming Potential) of methane is 28 while that of carbon dioxide is 1.

Our coconut's tree absorbs approximately 25 kg of carbon dioxide in a year, so it would absorb 100 kg over the same period. Hence, it would emit -100 kg of carbon dioxide. If these journeys happened at the same time, the net emissions would be 2140 kg of CO_2 thanks to Marco. The coconut wins this time.

Probability of reaching destination

We know the probability of Marco Polo reaching his destination is 100% as he has already done it. What we must calculate is the probability of a coconut going on this journey. This is the part you've been waiting for. Let's do this

About 62000000 metric tons of coconuts are produced annually. Among them, only about 6400 tonnes are produced annually in Senegal. Dividing this by the average mass of a coconut (1.5 kg) yields a production of $4266666.\bar{6}$ coconuts annually, which we will round up to 4266667. Now, I could approximate the number of coconut trees near the Senegal River to lower our sample space further, but I won't[6].

Now that we have our sample space, we can calculate the empirical probability of coconuts ending up in Europe. Because yes, coconuts have been seen off the shores of Ireland, the UK, even as far as Norway. 67 of them, to be exact. Among those 67 coconuts, three have ended up near our target location[7]. One

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[5] Plus, Marco would need to eat precisely 7665 coconuts for his journey, but our coconut would need to eat 0 Marcos. Clearly the coconut is more merciful, but sadly "Mercy" is not a measurable dimension so we can't give it a point ($\pi_{-\pi}$)

[6] I'm a fourteen-year-old who has just finished an exam that will determine the trajectory of the rest of my life. The exam itself ended on April 9th and I was too busy studying during the last two months to work on this, so I only have four days to write this project. Give this poor kid a break.

I'm being serious about this, by the way.

[7] Yes, I know these coconuts are likely from the Caribbean and not Senegal. To calculate the number of shits I give, check footnote 6

in Lusty Glaze on March 5, 2014; one in Penhale Sands on October 8, 2000; and one in Gwithian on February 12, 2016;. Hence, the empirical probability of a coconut from Senegal ending up at Cornwall is:

$$\frac{3}{4266667} = 7.031 \times 10^{-7}$$

We have now proven that coconuts can migrate. Not just theoretically, but empirically as well. Now, let's calculate the probability of the coconut returning. Since ocean currents are hard to predict (and footnote 6), I'll be calculating a hand-wavy estimate.

The distance from the North Equatorial current to the Irish Sea is roughly 17500 km. The probability that a coconut travels to Cornwall is 7.031×10^{-7}. The total distance the coconut travels is 27000 km, so there's 9500 km left to travel. 9500 km is about 35% of the journey. So, if we let the probability of the journey being complete be 'x',

$$x = 7.031 \times 10^{-7} \times 0.35 = 2.460 \times 10^{-7}$$

Note that this process of extrapolating likely yields an overestimate as the North Atlantic Subpolar Gyre is likely harder for a coconut than the North Atlantic Gyre. Once again, to calculate the number of shits I give, see footnote 6. Either way, Marco wins.

Conclusion

Let's count each side's score and see who wins.

Section	Winner	Points
Distance Travelled	Coconut	0-1
Time Taken	Coconut	0-2
No. of Crew	Marco Polo	1-2
Crew Mortality Rate	Coconut	1-3
Calories Consumed	Coconut	1-4
Greenhouse Gas Emission	Coconut	1-5
Probability of reaching destination	Marco Polo	2-5

The coconut wins. So yes, I am suggesting coconuts can migrate; better than Marco Polo, in fact.

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