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Do Lunar Cycles Influence Shark Attacks?

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Abstract: One recurring factor seemingly causing an increase in shark attacks is lunar cycles, especially the full moon. However, the potential association between shark attacks and lunar cycles has never been verified. Our results show that a correlation between shark attacks and moon cycles does not statistically exist. With no correlation between shark attack rates—independent of people's activities—and lunar cycles found, we also applied the same statistical procedures to surfer incidents only. The reasoning for narrowing the attacks to those on surfers was as follows: (1) Surfers indicate the best conditions to surf exist during the full and new moon. (2) Surfers are more exposed to shark attacks than non-surfers. However, as with the initial results, shark attacks involving surfers did not show any correlation to lunar cycles, neither did those involving non-surfers. These results indicate that potential triggers for shark attacks need to be studied in a more pragmatic manner, using, for example, mathematic approaches to test for global phenomena and then individual instances, leaving guess work largely aside.

Keywords: Full moon, lunar cycle, shark attack, tide.

1. INTRODUCTION

For many years, people have looked for factors causing shark attacks [e.g., 1-3]. These factors have largely been linked to basic factors, that is, food conditioning [e.g., 4], mistaken identity [5, 6], and others [e.g., 7]. However, with the exception of some individual events [e.g., 8, 9], none of these broader assumptions have ever been tested [e.g., 10]. Hence, it does not come as a surprise that many of these anecdotal triggers continue to be cited [e.g., 11]. One of the more persistent factors regularly appearing in popular and semi-professional science outlets is the linkage of lunar cycles to elevated shark attack numbers, especially full moon phases [e.g., 11-14]. That the behavior of animals [e.g., 15-17] and humans [e.g., 18-20] has been influenced by lunar cycles is known but it has not been scientifically determined if such an effect guides the bite rate of sharks, as well. In this study, we statistically analyzed the effect of lunar cycles on the number of worldwide shark attacks. The idea that moon cycles, especially full moons, were a trigger stemmed largely from a combination of different facts and communal wisdom. First of all and most prominently, incidents occurred by chance on full moon dates but were never compared according to the probability in relation to other days throughout a month [e.g., 10]. Furthermore, some landings of certain shark species—for example, blue sharks, *Prionace glauca*; makos, *Isurus oxyrhinchus*; and oceanic whitetips, *Carcharhinus longimanus*—increased during full moon [21, 22], or sharks, in general, showed activity in relation to lunar cycles [23] so that the likelihood of a full moon and shark-human interaction relation seemed plausible. It has also been suggested that some prey species avoid activity during a full moon to avoid shark attacks [24, 25].

2. METHODS

The attacks for the ten years between 2002 and 2011 that were filed with the Shark Research Institute's "Global Shark Attack File" have been evaluated [26]. Although shark attacks are a worldwide phenomenon throughout tropical, subtropical and temperate waters, some areas experience more incidents than others. It could be that more accident prone species frequent those waters or that some areas possess more favorable conditions than others for certain activities like e.g., surfing. Despite that such areas experience more shark attack incidents, these hot spots represent a worldwide distribution thus offering an unbiased approach. As it can be seen in Table **1**, the top 10 areas include locations from both hemispheres. Despite the fact that about 50% of all incidents occurred within US territories for the time examined, such areas should not be analyzed independently since it would 1) reduce the appearance of a potentially small effect making it possibly not recognizable and 2) reduce the analysis to the few months of the year where water temperatures are warm enough for people to enter the sea in that area. Furthermore, it has been shown [27] that e.g., the incident rate of California likely depends primarily on the migration routes of mature female white sharks, *Carcharodon carcharias*, hence this reflects a one species effect that does not show up e.g. in Florida where other species are involved in incidents [28].

Some cases were excluded from the evaluation e.g., where humans put themselves knowingly in harm's way, i.e.,

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Table 1. Percentage of Shark Incidents for the Ten Top Countries Between 2002 and 2011

Rank	Country	Percentage of Global Attacks
1	United States	50.3297
2	Australia	15.9341
3	South Africa	8.4615
4	Brazil	3.6264
5	Bahamas	2.1978
6	New Zealand	2.1979
7	Egypt	1.7582
8	Reunion	1.4286
9	New Caledonia	1.3187
10	Mexico	1.0989

Table 2. p-values of the Chi-square Test for Shark Attacks between 2002 and 2011 with Reference to Specified Time Periods Around a new and a Full Moon

	± 3d Mf	± 4d Mf	± 3d M_n	± 4d M_n	± 3d Mf/n	± 4d Mf/n
All Incidents	0.1399	0.6326	0.1423	0.0803	0.0153	0.0224
Surfers	0.0531	0.3116	0.4000	0.1133	0.0184	0.0155
Non-surfers	0.7543	0.9072	0.2293	0.3140	0.2019	0.2916

M_f = Full moon, M_n = New moon, $M_{f/n}$ = Full Moon and new Moon Combined. ± 3d, ± 4d = Number of days before and after M_f and M_n, Respectively

feeding sharks, fishing for sharks, or spear fishing. The remaining 910 cases were categorized as overall attacks (910 incidents), surfing attacks (319 incidents), and non-surfing attacks (591 incidents). Surfing incidents were separated because it is known that the highest waves, the best for surfing, occur around the full and new moon, bringing more surfers to the beaches than at other times. Furthermore, it has been shown that surfing carries a higher risk of being bitten than other beach-oriented activities [28, 29].

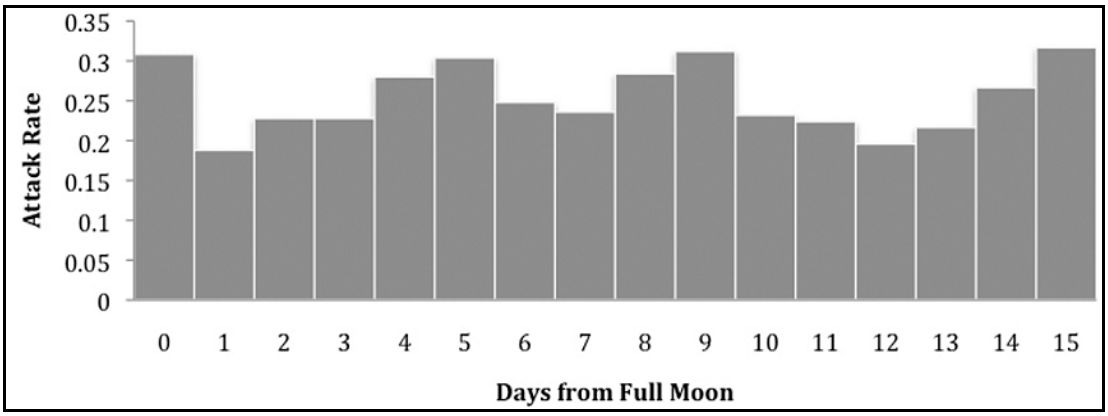
Because a correlation between shark attacks and lunar cycles could be tested in different ways, several questions were chosen to be answered: (1) Are shark attack rates higher in number during a full moon (Mf) than for the rest of the month? (2) Are shark attack rates higher in number during a new moon (M_n) than for the rest of the month? (3) Are combined shark attack rates for the full moon and new moon ($M_{f/n}$) higher in number than for the rest of the month? (4) For these previous questions, do the numbers for shark attack rates during Mf, M_n, and $M_{f/n}$ differ for surfers and non-surfers?

Since average wave height increases near Mf and M_n and then decreases again, the actual days of Mf and M_n were expanded to ± 3 days and ± 4 days from the actual Mf and M_n, and the shark attack rates on those days compared to attack rates during the remaining days of the month. The attack rate for any given day X was defined as the ratio between number of shark attacks on day X to number of times day X occurred within the studied time period. A Chi-square test for goodness of fit was used to compare the observed shark attack counts with the expected counts should the null hypothesis of equal shark attack rates for Mf and M_n be supported. The same approach was applied to the combined values of Mf and M_n combined ($M_{f/n}$).

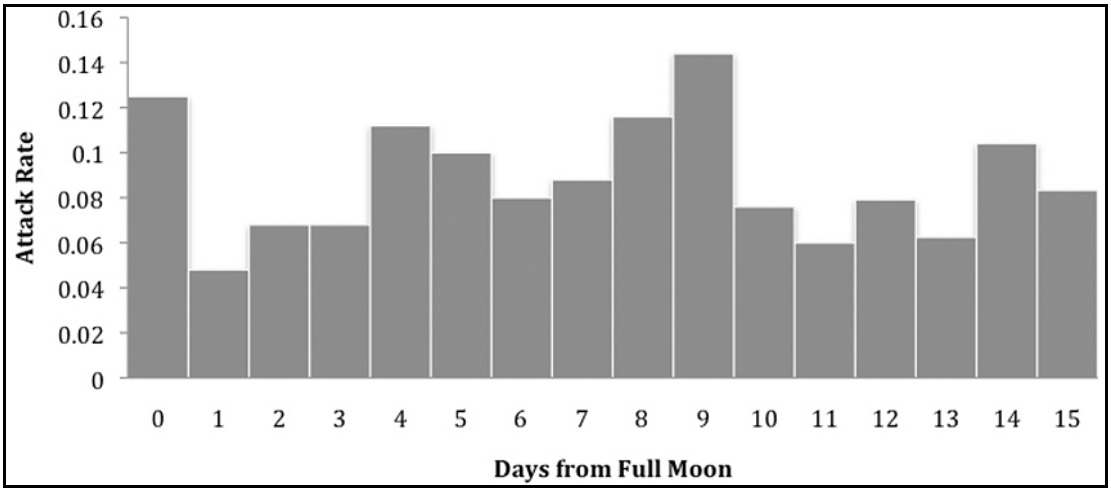
3. RESULTS AND DISCUSSION

The tests of a potential correlation between shark attacks and lunar cycles did not reveal significant evidence (with $p > 0.05$) that shark attack rates were higher during the ± 3 and ± 4 days around Mf or the ± 3 and ± 4 days around M_n (Table **2**). The same nonexistent lunar dependency was reflected, based on the ± 3 and ± 4 period around $M_{f/n}$. The observed proportions of shark attacks for the two time periods, 41.78% and 55.60%, respectively, were smaller than the expected numbers of 45.76% and 59.32%. Because the expected numbers are higher than the calculated ones for the chosen times, they confirm the nonexistence of a lunar-cycle-induced increase in attack rates.

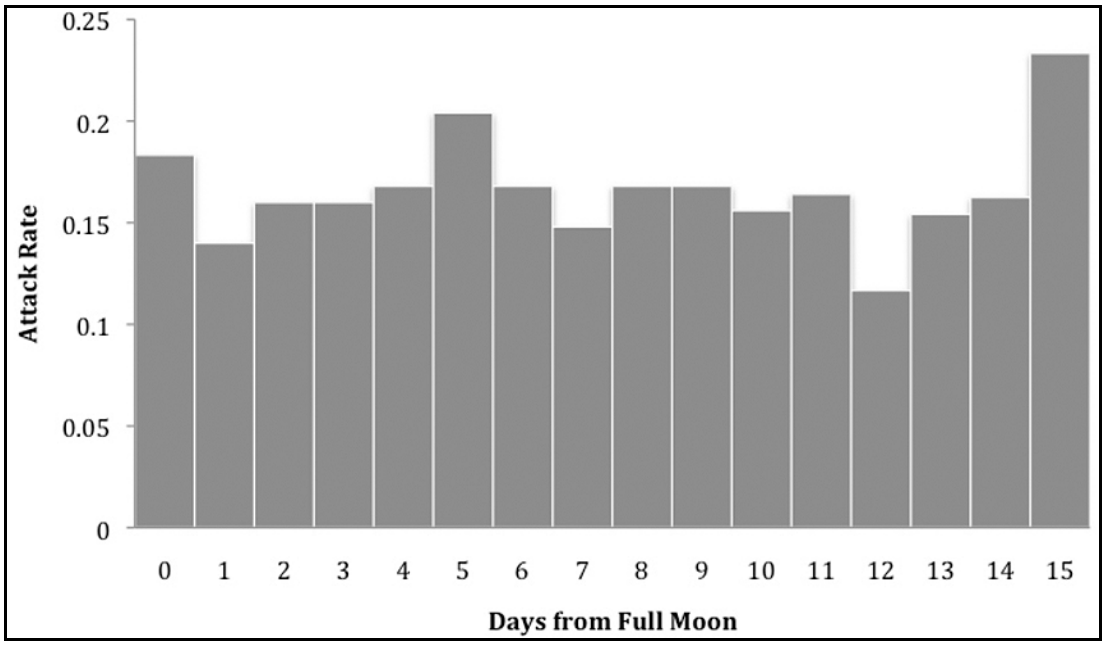
Although Mf, M_n, and $M_{f/n}$ did not show any correlation to shark attack rates, some periodicity was displayed when listing daily attack rates for "closeness to Mf" and "closeness to M_n" with day 0 representing a full moon and day 15 a new moon (Fig. **1**). It is understood that every "day" between 0 and 15 reflects any day of the week, based on the actual date of the lunar cycle, hence shows a rather constant number of people visiting beaches. Although Mf and M_n show elevated shark attack rates, these increases were not limited



a) all incidents combined



b) surfers only



c) non-surfers

Fig. (1). (**a**, **b**, **c**) Shark attack rates around the nearest full and new moon.

to Mf and Mn but reappeared on day 5 and day 9 as well, indicating a cycle of some kind (Fig. **1a**). Fig. (**1b**) representing surfers only also follows this cyclical effect around the same days. Although this cyclic patterns is less pronounced for non-surfers (Fig. **1c**), it is still present as well. The multiple peaks on the graphs make it clear that Mf and

M_n are not the only days on which shark attack rates were elevated; hence, the difference in the mean shark attack rates for M_f or M_n and the rest of the days of the lunar month is non-significant. Were M_f and M_n the only two peaking days for shark attack rates, then a significant difference would be shown in the results of the above test.

Although this analysis clearly refutes the claim that an increased rate of shark attacks occurs only during M_f or M_n, it evidently opens the door for research on a new problem, namely identifying the factors that trigger the cyclic effect seen in Fig. (**1**).

4. CONCLUSION

Finding triggering factors for shark attacks is important, and possibilities should be tested to defuse potentially dangerous situations before incidents occur [30, 31]. However, even if a correlation appears likely, as shown here with the potential effects of lunar cycles, without proper testing, such an idea remains merely an anecdotal guess at best as shown by these results.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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Declared none.

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