WELCOME

to our summer edition of Envirotalk.

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- Dr Mark Outerbridge provides an updated summary of Bermuda's **terrestrial scaled reptiles**
- Jenn Rose explains how genetic analysis has revealed something unique about Bermuda's **leafcutter bees**
- Dr Jonathan Nisbett challenges **what it means to be a good pet owner**
- Dr Mark Outerbridge describes a curious case of **Batesian mimicry**

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  - Our **News & Notices** for reminders and upcoming events
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Please contact the Envirotalk mailing list envirotalk@gov.bm if you would like to be added to it or if you wish to make suggestions for future articles.

BERMUDA'S TERRESTRIAL SCALED REPTILES

No doubt many of our readers are aware that Bermuda has a number of different kinds of lizards living here. Some are familiar to us because we grew up with them hanging around the house and yard while others are more recent arrivals and have yet to be seen with regularity. There are seven species currently established here (i.e. permanently living and breeding), six of which are introduced and one is indigenous.

The Bermuda skink *Plestiodon longirostris*, also called the rock lizard, is the local among this cast of characters. Unique to Bermuda, this reptile has descended from an ancestral form that once inhabited the eastern region of the U.S.A. millions of years ago and subsequently dispersed over oceanic waters to Bermuda following the emergence of the island[1]. Fossil evidence indicates that skinks were living here more than 400,000 years ago but paleontological and geological evidence suggest they may have been present here for 1-2 million years[2]. In the mid-nineteenth century skinks were described as being a relatively common sight living among old dry stack walls and stone heaps. Habitat alteration and predation have led to severe population declines and range fragmentation, leaving this species toeing the line of extinction. Bermuda's skinks are considered to be Critically Endangered by the International Union for the Conservation of Nature and were listed under the Bermuda Protected Species Act in 2007. Skinks have long cylindrical bodies with smooth, shiny scales, small legs, and clawed feet; characteristics which make them well adapted for burrowing and living among narrow rock crevices. Body colouration undergoes several changes during development. Hatchlings possess bright blue tails and have light brown bodies with two sets of white and black lateral stripes which extend from the head to the base of the tail. This colour phase lasts for the first year of life after which the juveniles begin to lose the blue tail colouration. As individuals mature they darken and the lateral stripes fade. Adult skinks have either a mottled dorsal pattern (remnant of the stripes) or a universally dark brown-black body and tail. Individuals in this last developmental stage also have a salmon pink or orange coloured chin and cheeks.

Adult Bermuda skink (top) and juvenile skink (right).
Photos: G. Garcia

The Jamaican anole *Anolis grahami* was deliberately introduced to Bermuda in 1905 to control insect pests and became so abundant that it is now the most frequently seen lizard. Things didn't quite go according to plan which prompted the Department of Agriculture to introduce the kiskadee flycatcher in 1957 to control the lizards. This only compounded the growing ecological problem (it turned out that

kiskadees were also really good at catching and eating skinks as well). Jamaican anoles have an island-wide distribution[3] and, when displaying their blue-green colours, are the most visually distinctive lizard on Bermuda. Adult males have a bright orange dewlap (a flap of skin under the chin) which they can extend and display. This reptile can also dynamically change its body colour to dark brown-black which, in conjunction with the orange dewlap, has misled some residents to mistake them for being skinks. Unlike skinks, which live almost exclusively on the ground, Jamaican anoles are frequently seen climbing vegetation, walls, and buildings (note that skinks also do not have a dewlap).

Jamaican anole (male)
Photo: M. Outerbridge

Antiguan anole (male)
Photo: A. Copeland

The Antiguan anole *Anolis leachii* is presently the second most commonly encountered lizard on Bermuda. Known locally as the Warwick lizard, it is by far the largest lizard here, with adult males growing to 30+ cm total length. This species was accidentally introduced to Bermuda during the early 1940s and was first encountered in Warwick[4] (hence the local common name), although it now has an island-wide distribution as well[3]. These lizards are also excellent tree climbers.

The Barbados anole *Anolis extremus* is another accidental introduction to Bermuda during the 1940s[4]. Little is known about the natural history of this lizard on Bermuda. Believed to have first gained entry via ships docking in the Royal Naval Dockyard, this species continues to live up to its local name 'the Somerset lizard' by only being found between the Somerset drawbridge and Dockyard[3].

Barbados anole
Photo: A. Copeland

Cuban anole (male)
Photo: J. Stroud

The Cuban anole *Anolis sagrei* is the fourth species of *Anolis* lizard to have become naturalized on Bermuda[5]. It was first encountered in 2011 by a farmer who was unloading a container that had been shipped from the U.S.A. It was caught and killed and no other Cuban anoles were found at that time. This species was encountered again in 2013, this time at a local plant nursery in Paget. Examination of the property revealed the presence of a thriving colony comprising all age classes (hatchlings to reproductively mature adults) which suggested they had been there for a few years. It also suggested that this species was here to stay. In 2014 a second large colony was discovered at a lumber yard in Pembroke (confirming its immigration status). Both colonies were likely founded by lizards arriving as stowaways on imported containers. Since then two additional colonies of Cuban anoles have been found; one on Somerset Island and the other at the airport dump. It is expected that this lizard will become very common and have an island-wide distribution in the future.

The Tropical house gecko *Hemidactylus mabouia* and the Mediterranean gecko *Hemidactylus turcicus* are the most recent non-native lizards to have become naturalized on Bermuda[6]. The former was first reported in November 2007 (at the airport); the latter in March 2011 from a warehouse in Hamilton. These geckos are nocturnal lizards native to continental Africa (*H. mabouia*) and the Mediterranean basin (*H. turcicus*); however they have been introduced into many other parts of the globe. They are associated with human development and are highly adaptable, thereby becoming successful invaders throughout their non-native range. House geckos are often found lurking on walls and ceilings near light fixtures, waiting to ambush moths and other nocturnal insects. Both species superficially resemble one another but the Mediterranean gecko usually has the bumpier skin. Like all house geckos they are rather flattened, with large heads, bulging eyes, vertical pupils, and somewhat translucent bellies. Local surveys have revealed that these geckos are now found in all nine parishes. As their abundance grows expect to hear their chirping calls during future sultry summer evenings.

Tropical house gecko (left) and Mediterranean gecko (right)
Photos: M. Outerbridge

It would be remiss of me if I didn't briefly mention two other species that have arrived here over the years, but failed to become established. In February 2000 a young green iguana *Iguana iguana* was found wandering across the sea docks in Hamilton where a container ship had recently unload its cargo. It was quickly captured by a dock worker, taken to the Bermuda Aquarium Museum and Zoo, and accessioned into the animal collection. Given the name 'Stumpy' by BAMZ staff, (which later changed to 'Stumpette' after she laid an egg in captivity), this iguana can still be seen today basking in the Caribbean exhibit.

History repeated itself years later when an adult male American green anole *Anolis carolinensis* was caught on the Hamilton sea docks in March 2016. This lizard, yet another stowaway on the global network of trans-continental shipping, wasn't as lucky as Stumpette. He resides in the Natural History Museum among the shelves of pickled specimens.

The Department of Environment and Natural Resources is always interested in learning about unusual reptile sightings. Please send reports as an email to environment@gov.bm, with photographs if possible.

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BERMUDA'S LEAFCUTTER BEE: A UNIQUE LINEAGE REVEALED THROUGH GENETIC ANALYSIS

Recent genetic analysis has revealed intriguing insights into Bermuda's leafcutter bee, *Megachile pruina pruina*, suggesting that the population on the island may represent a unique lineage no longer found among populations in its native range in the United States. However, a preliminarily population genomic analysis hints that its genetic diversity may be comparatively lower than that of its mainland counterparts. These findings provide valuable insights into the genetic composition of the population in Bermuda and underscore the need for further research to understand its natural history fully. Moreover, it highlights the importance of assessing potential implications and implementing conservation measures for its long-term survival.

A female Bermuda leafcutter bee harvesting nesting material to make her nest. Photo: Miguel A. Mejias

Despite over 20,000 bee species globally[1] our understanding of their natural history and diversity remains largely unexplored and unknown. This knowledge gap presents a significant challenge as many species may vanish without a trace. Among these species is Bermuda's leafcutter bee. This insect is localized in the Castle Harbour Islands Nature Reserve and faces similar threats to numerous terrestrial species on the island, including habitat reduction, invasive species, and climate change. Despite previous mentions of this exclusive bee species in past EnviroTalk newsletters, summarizing its known natural history (Summer 2018, Vol. 82, No. 2) and emphasizing its crucial role as a pollinator (Autumn 2022, Vol. 86, No. 3), no direct research efforts have been undertaken, despite being listed as a Level 2 "Vulnerable" species under the Bermuda Protected Species Act. The lack of research on this species raises a critical question: How can we develop effective conservation strategies to protect a species if we lack fundamental knowledge about its biology and ecology?

A male Bermuda leafcutter bee. Colors vary between males and females, as well as geograpical location of the species. Photo: Richard Brewer

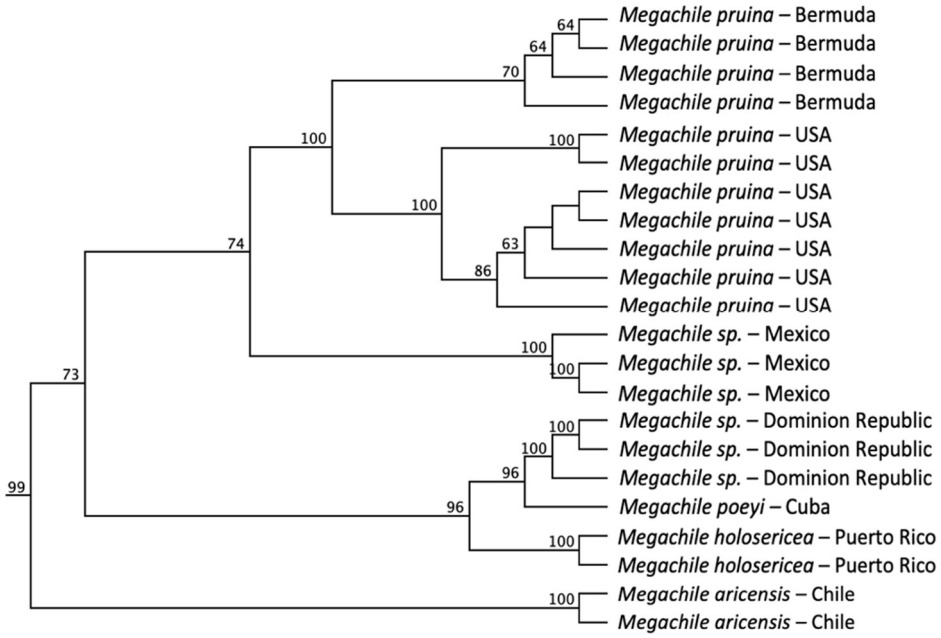
As part of my MSc thesis conducted at the University of Copenhagen, Denmark, I took the first steps to establish a baseline understanding of the taxonomic status of Bermuda's leafcutter bee. Through DNA extraction and sequencing, I explored the species' evolutionary history to uncover the potential origins of Bermuda's source population. Additionally, I conducted an assessment to evaluate the genetic diversity of the bee population on the island to see whether it is at risk of low diversity. In recent years, molecular approaches have gained significant traction in bee conservation, providing support for species descriptions and classification of complex taxonomic groups. Furthermore, they serve as invaluable tools for monitoring vulnerability to landscape changes and observing susceptibility to potential inbreeding risks that may ultimately lead to extinction.

Insight into the Leafcutter Bee's Evolutionary History and Origins

A phylogenetic analysis was constructed using mitochondrial COI sequences obtained from *M. pruina* individuals, as well as sequences from other leafcutter bee species. This was done to understand its relationship with other bees within the leafcutter bee genus *Megachile.* The resulting tree revealed a strong separation between Bermuda's population and the United States. Interestingly, no significant differences were observed among United States populations, suggesting a revision of *M. pruina* current subspecies (an additional subspecies, *Megachile pruina nigropinguis,* describes dark variants in Texas). Bermuda's *M. pruina* samples were more closely related to an unidentified species collected in Mexico as well as two species collected in three locations in the Caribbean (*M. holosericea* and *M. poeyi*). Unfortunately, the inability to identify the Mexican species has left a mystery surrounding this relationship.

The origins of Bermuda's leafcutter bee become particularly intriguing when considering the island's isolation and considerable distance from the mainland. Further analysis estimating divergence could provide insights into the bee's arrival in Bermuda, while previous studies indicate that *M. pruina* in the United States evolved around 4-9 million years ago[2]. Oceanic insect dispersal involves flight, wind, rafting, and transportation by other animals or humans. Considering the bee's medium body size and cavity nesting along coastal habitats, it is possible that Bermuda's founding population arrived via the Gulf Stream, similar to other species found in Bermuda. Its success establishing in Bermuda may be attributed to its generalist foraging strategies, as well as the prevalence of flora originating from the eastern North American and Caribbean regions in Bermuda, which could have played a vital role in facilitating the bee's adaptation and utilization of plant resources.

While the leafcutter bee population in Bermuda did not originate from the populations analyzed, it is plausible that the source population either was not sampled or became extinct. Considering its close relationship to Caribbean and Latin American species, it is also possible that *M. pruina* might have historically existed or still exists in these regions, as the true distribution of the species in North America has not been extensively studied. If the source population no longer exists, the bee population in Bermuda could potentially represent a unique and isolated evolutionary lineage, echoing the familiar narrative of the Bermuda skink *Plestiodon longirostris.*



Excerpt of a *Megachile* phylogenetic tree constructed to show the relationship between Bermuda *M. pruina*, United States *M. pruina* and other *Megachile* specimens within the genus *Pseudocentron*. Numbers above each node represent maximum-likelihood bootstrap values, with a strong bootstrap value of 100 separating Bermuda and the United States.

Assessing the Genetic Diversity and Associated Risks

The second portion of the thesis aimed to investigate the genetic diversity of Bermuda's population. Small and isolated populations are highly vulnerable to extinction risks due to limited genetic variation and environmental pressures. Bermuda's leafcutter bee population already faces multiple challenges so to accurately evaluate the long-term sustainability of the population, it is crucial to further explore genetic aspects and their implications.

In a preliminary analysis, the mitochondrial genomes of the leafcutter bees were examined within and between Bermuda and United States populations. This revealed lower genetic diversity in Bermuda than in the United States. Bermuda's population exhibited lower-than-expected rates in comparison to studies on other North American bee species[3] but these numbers could have been the results of my relatively low sample size. Low genetic diversity raises concerns about the population's fitness and the potential occurrence of severe inbreeding, possibly facilitated by diploid male production[4]. Although the male Bermuda leafcutter bees examined in this study were not diploid, the limited sample size warrants further analysis and investigation.

Preserving unique alleles becomes crucial as populations decline, as reintroduction efforts from external donor populations become less effective. Introducing *M. pruina* individuals from the United States can enhance Bermuda's genetic diversity and mitigate the loss of genetic variation and the risk of a 'diploid male vortex' [5]. This is a phenomenon of inbreeding that increases the production of sterile diploid males until a population becomes extinct. Given the absence of significant differences among United States populations, any sampled region theoretically has the potential to serve as a donor population.

In summary, these results provide support for its current protection status while also suggesting the need for further research as the bee has greater uniqueness and fragility than initially thought. While there is a possibility that this species may be an endemic subspecies, conducting a comprehensive morphological analysis is recommended to support the molecular findings. Apart from Mitchell's initial description of a female specimen nearly 100 years ago[6], no comprehensive morphological analysis exists of the Bermuda leafcutter bee. As highlighted in the 2017 Government of Bermuda "Recovery Plan for the Leafcutter Bee, *Megachile pruina pruina*, on Bermuda," it is crucial to continue research efforts, including population assessment, exploration of the true habitat range, and examination of nesting and foraging strategies, to prevent potential population declines, and improve current conservation measures. Given that only 3.7% of Bermuda's insect species are considered endemic[7], it is vital to conserve and protect this unique bee exclusive to the island.

I would like to thank Dr. Mark Outerbridge and Dr. Robbie Smith for supporting and providing Bermuda bee samples for this study. I would also like to thank Dr. Elijah Talamas (Florida State Collection of Arthropods) and Sam Droege (United States Geological Survey: Eastern Ecological Science Center) for providing bee samples from the United States.

The results are expected to be published in the near future.

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THE QUESTION OF PET OWNERSHIP

Recently, an article entitled *The Case Against Pet Ownership*[1] found its way into my inbox. It was written by Kenny Torrella and appeared in the April 2023 edition of *Vox,* an online magazine. Then, about a week or two later, I heard a radio interview[2] that was sparked by the *Vox* article. Together, the article and the interview introduced Jessica Pierce, bioethicist and author of *Run, Spot, Run: The Ethics of Keeping Pets*[3].

Ms. Pierce and Mr. Torrella challenge what it means to be a good pet owner. They ask whether our pets are actually quite miserable, and raise the questions of whether people should discontinue pet ownership, or at least, substantially reduce the number of pets in our society.

In response to the above questions, I expect to hear a range of comments, including:

1. 'Yes', some pets are kept in miserable conditions, and we must keep animals out of the hands of those who are unable/unwilling to properly care for them.
2. Puppy and kitten mills ought to end, and people should only get a dog or cat if they have the time, money, patience, and energy to give it a good life.
3. My pet is not miserable, but is a spoiled family member, who sleeps in my bed, has the finest diet, a great body condition score, is walked twice daily, has regular vet visits. My pampered pet lives quite the happy life.

I solidly agree with the first two comments, and I have very recently witnessed examples of neglect that have arisen out of ignorance or financial inability to provide care. Sometimes, incidents of abandonment are acknowledgements by owners that they cannot provide care, not even to a standard that they believe necessary.

To the owners claiming to have happy, spoiled, pampered pets, the Pierce and Torrella offer arguments to say 'Ahhh…Not so fast; Don't be so sure.' Torrella writes: "*Pierce's work aims to direct our gaze to where more subtle, but far more common, forms of everyday neglect and cruelty lie. To Pierce, even well-meaning pet owners may have a lot to answer for: punitive training, prolonged captivity and extreme confinement, mutilations (declawing, ear and tail docking), outdoor tethering, lack of autonomy, verbal abuse, monotonous and unhealthy diets, lack of grooming, and inadequate veterinary care.*" Wow, there's a lot in that last sentence that ought to spur some examination of our own practices. Do you see any of your actions in that list?

Humans keep a broad range of animals as pets, including dogs, cats, birds, rabbits, guinea pigs, horses, and fish. Humans draw many benefits from the human-animal bond, and our pets add joy to *our* lives. But is there reciprocal joy for the animal? Are we doing a good job with them? Are we adequately meeting their needs?

Given the busyness of our lives, with work, school, family, social commitments, errands, chores, entertainment and time away from home, how much time do we really spend with our pets? How much time do we spend enriching their lives? We seek and receive their companionship for a few minutes, or perhaps walk or ride them for an hour or so, but when that is done, what else fills their days? Our animals are largely left to themselves for a very large portion of the day.

I recently watched a litter of puppies who were let loose inside of a fenced, outdoor area. They were curious about the other animals they could see outside of the fenced area; they ran and played and

generally frolicked around; they followed their noses wherever interesting scents lead them. In brief, they were free to be….puppies. How often does it occur that any of our pets are free to be their authentic selves? I offer that our pets are rarely given such an opportunity. Our pets are animals in a human world, subject to the rules that we impose upon them. They are not free to roam, explore, socialize. There are very good reasons for these rules, but they are restrictions nonetheless.

I know of a person who is home recovering from a medical procedure. His physical condition limits his activity and he complains of being bored. There are a variety of options available to him to provide mental stimulation: television, Netflix, surf the internet, seek YouTube videos of hobbies, cook, knit, solitaire, short walks…..and the list goes on. However pets find themselves in a situation of similar limited activity and mental stimulation. Are they bored and frustrated by daily monotony? Our animals don't have the same variety of options, nor the autonomy to choose. If you happen to be nearby (as you were during the work from home lockdown), you'll likely experience the attention-seeking behaviours, like the seemingly never ending 'pet me now' gesture, or barking, or the cat that begins walking all over your keyboard while you're trying to type. The squeaky toy, the rawhide chew bone, the stuffed toy will quickly lose their appeal, and yield to staring out of the window, yawning, and sleepiness. More pronounced boredom may manifest itself in variety of ways: barking, howling, whining, repetitive pacing back and forth, licking, self-mutilation, digging, destructive chewing, altered personality.

The questions raised by Pierce and Torrella are quite provocative, and the answers may be painful to face, for individuals and our broader society. There are also implications for zoos and aquaria. Well-run facilities do provide environmental enrichment, operate to professional standards, and contribute to public education, scientific knowledge and species conservation. Pet ownership cannot claim any of these laudable goals. I have no expectation nor desire to see pet ownership end, but I would like to see it improved dramatically. I invite readers to check out Ms. Pierce's book, Mr. Torrella's article or at least spend 8 minutes or so with the *Here and Now* audio interview for a prospective you may not have

considered previously. Perhaps your thoughts and beliefs will be challenged. There will also be ideas on how you can add a little joy to the life of your companion and beloved pet.

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A SHEEP IN WOLFS CLOTHING

From a biological perspective, mimicry is a resemblance between one organism and another organism (or object) which bestows survival benefits to the mimic. The majority of known mimics are insects, the most famous being stick insects and leaf insects; however some mimic species look remarkably similar to stinging insects. A local example is the drone fly (aka hover fly) *Eristalis tenax* which bears an uncanny resemblance to the European honeybee *Apis mellifera*. This resemblance is called Batesian mimicry and describes the fascinating situation where a harmless species (the fly) has evolved to imitate a harmful species (the bee). Animals that have learned to stay away from a painful sting by not eating bees are much more likely to stay away from drone flies as well. In addition to looking like honeybees, drone flies might also provide us with an agricultural service; recent research[1] indicates that drone flies can function as field-crop pollinators for yellow flowering plants like pak choi and onions. You can learn more about Bermuda's pollinating insects by reading the 2022 Autumn edition of Envirotalk (Vol. 86 No. 3).

Drone fly
Photo credit: Internet image

European honeybee
Photo credit: Phil Bendle

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Dr Mark Outerbridge
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NEWS & NOTICES

Call to Earth TV series featuring conservation on Bermuda

Call to Earth is a CNN editorial series committed to reporting environmental challenges facing our planet and the dedicated people who are protecting it. The shows focus on conservation initiatives, environmentalism, and sustainability and are told across multiple media platforms including TV, their website (https://edition.cnn.com/interactive/call-to-earth/#/) and social media. The latest documentary will be about Bermuda and the efforts that local conservationists have carried out in order to prevent the extinction of our endemic skink, land snails, and petrel. The show is expected to air on June 24th.

Spearfishing statistics reminder

Recreational spear fishers are reminded that spearfishing statistics should be submitted monthly using the online portal at www.fisheries.gov.bm. There should be an entry for each date / location that you fished, and a "No fishing" entry for the final day of any month in which you did not fish. Your catch statistics must be up to date through at least the end of July if you are applying for a spearfishing licence for the upcoming season, which starts on September 1st. Applications will be taken any time from Monday, August 7th. Please call 293-5600 or email fisheries@gov.bm if you are having difficulties accessing the portal.

Recreational lobster diving licences

The 2023-2024 lobster season will begin on Friday, September 1st. DENR will be taking applications for recreational lobster diving licences for the upcoming season at the main offices in the Botanical Gardens from Monday, August 7th 2023. As with the last few seasons, there will be a cap on the number of licences, which will be issued on a first come, first served basis.

Please note that if you held a lobster diver licence for the 2022-23 season and did not submit any statistics then you will NOT be granted a licence for the upcoming season. This decision has been made at the Ministerial level, in consultation with the Marine Resources Board, and exceptions cannot be granted by DENR staff. Anyone who acts in an abusive manner towards any staff member will be given a two-year suspension.

Seasonally closed fish protected areas

The North Eastern and South Western Seasonally Closed Areas, also known as 'the hind grounds,' are currently closed to fishing, and will remain closed through the 14th of August 2023 (the first day they can be fished is August 15th). Also, the extended closure areas, known as the 'grouper boxes', within the seasonally closed areas are currently closed to fishing, and will remain closed through the 30th of November 2023. The coordinates for these areas can be found at www.gov.bm/bermudas-no-fishing-areas

PLANTING CALENDAR – WHAT TO PLANT IN THE SUMMER

VEGETABLES

July
Beans, carrots, tomato

August
Beans, broccoli, brussel sprouts, cabbage, carrots, kale, leeks, mustard greens, sweet & hot peppers, radish, rutabaga, tomato

September
Beans, broccoli, brussel sprouts, cabbage, carrots, cauliflower, celery, chard, cucumber, eggplant, kale, leeks, mustard greens, parsley, sweet & hot peppers, potatoes, radish, rutabaga, tomato, turnip




FLOWERS

July, August, & September
Celosia, cosmos, gazania, globe amaranth, impatiens, marigold, salvia, snow-on-the-mountain, vinca and zinnia