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Feeding Behavior of *Coralliophila* sp. on Corals Affected by Caribbean Ciliate Infection (CCI): A New Possible Vector?

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Abstract: Coral reefs in the Caribbean are known to be affected by many coral diseases, yet the ecology and etiology of most diseases remain understudied. The Caribbean ciliate infection (CCI) caused by ciliates belonging to the genus *Halofolliculina* is a common disease on Caribbean reefs, with direct contact considered the most likely way through which the ciliates can be transmitted between infected and healthy colonies. Here we report an observation regarding a *Coralliophila* sp. snail feeding in proximity to a cluster of ciliates forming the typical disease band of CCI. The result of this observation is twofold. The feeding behavior of the snail may allow the passive attachment of ciliates on the body or shell of the snail resulting in indirect transport of the ciliates among colonies, which makes it eligible as a possible disease vector. Alternatively, the lesions created from snail feeding may enhance the progression of the ciliates already present on the coral as well as promoting additional infections allowing pathogens to enter through the feeding scar.

Keywords: coral disease; *Halofolliculina*; transmission mechanism; Bonaire; *Acropora*

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Coral diseases represent a serious threat for coral reefs worldwide, with the Caribbean considered a "hotspot" of disease outbreaks [1]. Currently, the coral reefs of the Caribbean are experiencing an outbreak of stony coral tissue loss disease (SCTLD) that originated on the reefs of Florida in 2014 [2] and is spreading across the Caribbean resulting in extensive colony mortality [3–6]. Despite the devastating effect this disease has had on coral reefs, our understanding of its ecology, pathogenesis, and etiologies is limited, making it difficult for resource managers to make decisions on how best to maintain these critical resources. As example, understanding disease spread among individual colonies or coral populations would be a critical factor in developing management actions to slow down or stop disease and the resultant mortality, yet disease transmission dynamics are still understudied [7].

Many studies have suggested that coral-feeding animals can promote disease transmission among colonies on a reef. Several families of coral reef fishes have been observed in the field feeding on coral disease lesions including black band disease (BBD) [8,9], brown band disease (BrB) [10] and stony coral tissue loss disease [11]. Corallivores feeding on disease lesions could transmit the pathogen by subsequently feeding or defaecating on a non-diseased colony and this has been suggested as a mechanism of black band disease transfer by butterflyfishes [9,12] as well as spreading the trematode parasite that causes *Porites trematodiasis* in Hawaii [13]. Numerous types of invertebrate corallivores (snails, nudibranchs, fireworm, crown-of-thorns seastars) have also been implicated in disease

transmission, either directly [1,14,15] or indirectly via feeding scars which subsequently develop disease [16–21].

Halofolliculinid ciliates can cause progressive tissue loss on corals; this disease is termed skeletal eroding band in the Indo-Pacific and Caribbean ciliate infection in the Caribbean [22]. Caribbean ciliate infection (CCI) was first reported in 2006 [23], and it can affect ~4 to 8 % of corals as observed in Venezuela and Curaçao [22]. It manifests as a dark-grey band 1–10 cm thick, located at the interface between recently exposed skeleton and apparently healthy coral tissue showing the characteristic spotted appearance of the clustering ciliates [24,25] (Figure 1a,b). *Halofolliculina* ciliates have a life cycle represented by two distinct phases: a sessile ciliate (encased within a lorica), and a motile larval phase. During replication, the de-differentiation of the sessile feeding trophont results into a simple motile phase, which then divides asexually into two motile swarmers that may move using ciliary locomotion and disperse [26]. Transmission of ciliate infection among coral colonies occurs on direct contact between a healthy and infected colony [26] and through the water column if the health colony has a prior injury of any origin [27,28]. Ciliates at the sessile stage have also been found embedded in the shells of a number of corallivorous gastropods which may serve as passive vectors of the disease [22].

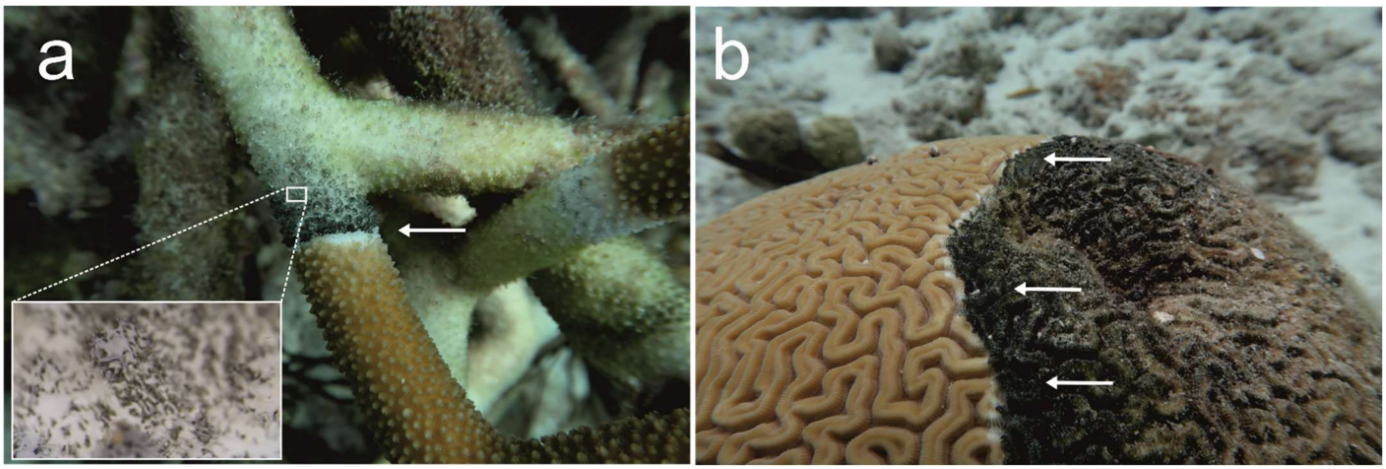

Figure 1. It shows the typical appearance of corals affected by CCI. The arrows indicate the cluster of ciliates forming CCI dark-grey bands located at the interface between recently exposed skeleton and apparently healthy coral tissue on (**a**) *Acropora cervicornis* and (**b**) *Diploria labyrinthiformis*.

Here we report on an observation made in Bonaire in 2019, in which a *Coralliophila* sp. snail was observed feeding on coral tissue at the edge of the cluster of ciliates forming typical disease bands of CCI (Figure 2a,b). The snail species in question is probably *C. galea* (Dillwyn, 1823), previously misidentified as *C. abbreviata* (Lamarck, 1816), which is so far the only *Coralliophila* species reported from Caribbean *Acropora* spp. [29–31]. This observation creates the possibility that transmission of CCI may also be facilitated by snail activities. Lesions created by snail predation may open-up wounds in the coral which can then be colonized by the ciliates at the swarmer stage. Alternatively, snails are attracted to injured coral tissue [32] so coral lesions created by CCI could attract snails and allow passive attachment of ciliates on the body, or shell, of the snail resulting in indirect transport of the ciliates among colonies. *Coralliophila* species have been implicated as a potential vector of white band disease [15,33], white pox disease [1], and white plague disease [34] in the Caribbean, as well as to disease development in *Porites cylindrica* in the Indo-Pacific [20]. Our observation adds to the growing body of evidence on the role that snails play in disease transmission, however, the extent to which *Coralliophila* may be involved in the pathogenesis of halofolliculinid ciliate infection in Bonaire needs further investigation.

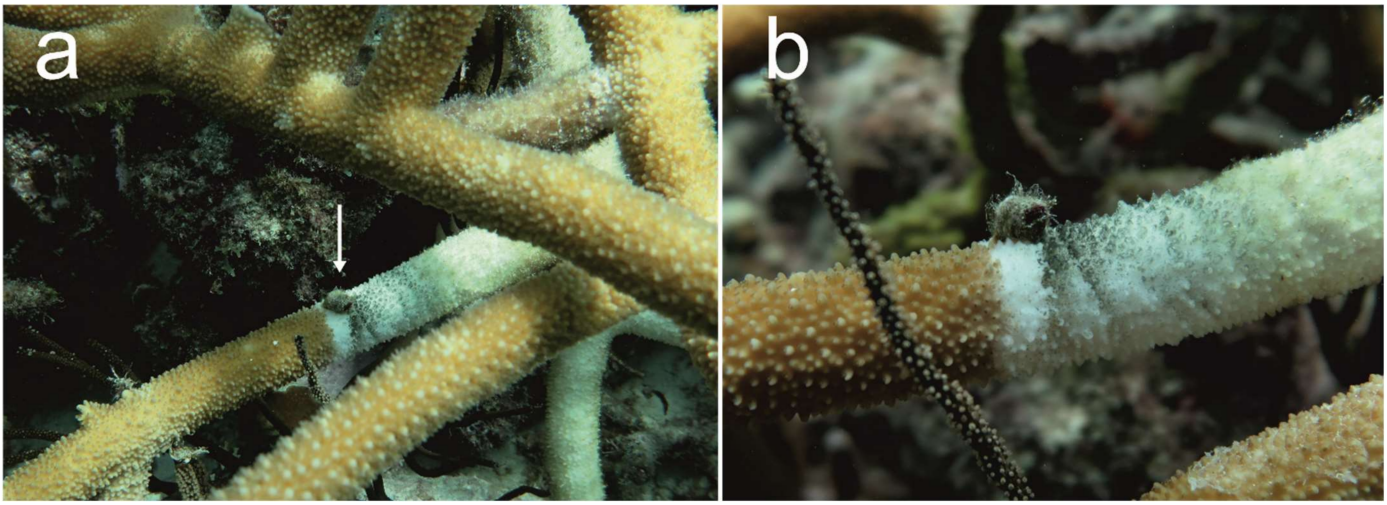

Figure 2. (**a**) *Coralliophila* sp. snail feeding in proximity of cluster of ciliates forming the typical disease band of CCI; (**b**) close-up of the snail's feeding behavior.

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