Coral Restoration and Growth Performance at Samui Island, Southern Thailand

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ABSTRACT

Restoration and growth performance of several coral species at four fringing reef sites (Hua Thanon, Lamai, Maenam, Nathon) in Samui Island were conducted. At each site, five coral colonies on a 1 X 0.5 m^2 plastic netted quadrat (n = 6) were restored and placed at the coral reef from November 2014 to May 2015. Measurement of the initial and final sizes in terms of length and width of corals revealed that at Maenam reef, length and width of *Fungia fungites* and *Lobularis* sp. increased (*F. fungites*: L: Nov. 2014- 9.16±0.46, May 2015- 10.32±0.56, W: Nov. 2014- 8.75±0.46, May 2015- 9.58±0.51; *Lobularis* sp.: L: Nov. 2014- 11.86±0.17, May 2015- 20.87±0.23, W: Nov. 2014- 5.52±0.65, May 2015- 16.79±0.26). At Lamai reef, *F. veroni* length increased (Nov. 2014- 9.01±0.12, May 2015- 10.82±0.04). *A. millepora* and *P. decussata*, both length and width increased (*A. millepora*: L: Nov. 2014- 10.81±0.54, May 2015- 14.85±0.86, W: Nov. 2014- 6.71±0.60, May 2015- 9.39±0.88; *P. decussate*: L: Nov. 2014- 11.90±0.95, May 2015- 16.31±1.35, W: Nov. 2014- 8.03±1.04, May 2015- 10.48±1.00). At Hua Thanon reef, *F. fungites* and *A. millepora* length and width increased (*F. fungites*: L: Nov. 2014- 7.26±0.83, May 2015- 8.29±0.94, W: Nov. 2014- 6.55±0.74, May 2015- 7.70±0.91; *A. millepora*: L: Nov. 2014- 10.66±1.30, May 2015- 14.49±1.77, W: Nov. 2014- 8.32±1.49, May 2015- 12.01±2.11). At Nathon reef, *P. lutea* length increased (Nov. 2014- 9.87±0.67, May 2015- 12.55±1.10), while both length and width of *F. fungites* increased (L: Nov. 2014- 11.12±0.61, May 2015- 12.29± 0.83, W: Nov. 2014- 10.28±0.49, May 2015- 11.10±0.61). Among sites, length increment was higher at Lamai reef than at Nathon and Maenam reefs, and width increment was also higher at Lamai reef than at Nathon reef. Among species, *Lobularis* sp. growth increment was higher than other coral species.

Keywords: Corals, coral length and width, growth increment, Samui Island

INTRODUCTION

Coral reefs are widely recognised as highly productive, ecologically valuable, and economically important ecosystems. Over the last decades, coral reefs worldwide are experiencing a recent period of decline (Szmant, 2002). The main factors for the

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degradation of corals are climate change, over fishing, and other anthropogenic factors (Wilkinson, 1998; Bellwood *et al*., 2004; Juhasz *et al*., 2010; Chumkiew *et al*., 2011). Reefs in South-East Asia are classified as the most species-rich coral reefs on earth (Burke *et al*., 2002). More than 80% of all coral reefs are at risk and over half of them at high risk (Bryant *et al*., 1998, Burke *et al*., 2002). A bigger part of these destructive activities are consequences of the growing tourism industry, one of the fastest growing sectors of the global economy (Cesar *et al*., 2003).

In Thailand, there has been a rapid change in coral reef use from traditional fisheries to tourism activities such as diving, underwater photography, glass-bottom vessels, sea walkers and sport fishing (Yeemin *et al*., 2006). Due to poorly managed tourism, coral reefs in Thailand are experiencing unprecedented rates of degradation from anchor damage, garbage accumulation, diver damage and wastewater discharge from hotels and resorts (Yeemin *et al*., 2006, 2009, 2013). Many institutions and organisations have been involved in restoring degraded coral communities in Thailand (Yeemin *et al*., 2006, 2009, 2013). Coral reefs at Samui Island have undergone a rapid decline in coral cover due to high sedimentation, nutrient enrichment, low water quality, overfishing and tourism (Yeemin *et al*., 2013).

Several techniques have been used for reef restoration such as transplantation of living coral colonies (Harriott and Fisk, 1995; Rinkevich, 2000), branching ceramic stoneware modules (Moore and Erdmann, 2002), and electrolysis to accelerate the deposition of calcium carbonate and enhance the growth of transplanted coral (Hilbertz, 1992; van Treeck and Schuhmacher, 1997, 1999). In Thailand, many coral restoration techniques have been used such as coral transplantation, translocation, and electrolysis (Sirirattanachai, 1994; Sirirattanachai *et al*., 1994; Chunhabandit *et al*., 1999; Yeemin and Chunhabandit, 1999). The main goal of coral restoration is to rescue the damaged corals as rapidly as possible by placing them in a safe location near their habitats until there is an opportunity to transplant them back on their own habitat (Jaap, 2000). In this study, several coral species were restored at four fringing coral reef sites at Samui Island, southern Thailand for six months, and checked their growth performance.

MATERIALS AND METHODS

Study sites

Four coral reef sites at Samui Island, Southern Thailand were selected for this study, namely Hua Thanon (9.443201°N, 100.025397°E), Lamai (9.572706°N, 100.014652°E), Maenam (9.559450°N, 99.974807°E) and Nathon (9.532030°N, 99.933627°E). Samui Island is the largest island in Thailand with very turbid water and 2-5 m water transparency. The coral community at these four sites occur at 1-5 m water depths. This study focused on shallow coral communities for two reasons. First, shallow coral reefs were more subjected to high turbidity and strong impact from coastal development and boat transportation. Second, depth was constrained to 1-5 m to minimise the variance due to depth-associated influences on coral growth (Huston, 1985).

Restoring corals and measuring growths

At each site, coral colonies (*Acropora millepora*, *Favia veroni*, *Fungia fungites*, *Lobularis* sp., *Pavona decussate*, and *Porites lutea*) were randomly collected and identified up to genus or species level. Five coral colonies were placed on a 1 X 0.5 m^2 plastic netted quadrat (n = 6), and photographs were taken with a reference scale (cm). Six quadrats were placed under water at each site in November, 2015. In May, 2015, photographs of all coral colonies were taken with a reference scale. The initial and final maximum lengths and widths of all corals were measured from the photographs by using the GIMP program in the lab, and analysed their growth performance.

Statistical analysis

t-tests were used to test the differences in length and width growth performances of each coral species in all sites. Multivariate Analysis of Variances (MANOVA) with Post Hoc Tukey tests were used to test the effects of sites and coral species on coral length and width growth performances. Data were reported as mean values ± standard error (SE). All significance tests were two tailed and tests were considered statistically significant at $P<0.05$.

RESULTS

Growth of coral at four sites

At Maenam reef, length (L) and width (W) of *F. fungites* and *Lobularis* sp. increased significantly (*F. fungites*: L: Nov. 2014- 9.16±0.46, May 2015- 10.32±0.56, *t*=-5.17, d.f.=14, *P*=0.001, W: Nov. 2014- 8.75±0.46, May 2015- 9.58±0.51, *t*=-4.43, d.f.=14, *P*=0.001; *Lobularis* sp.: L: Nov. 2014- 11.86±0.17, May 2015- 20.87±0.23, *t*=-22.52, d.f.=1, *P*=0.028, W: Nov. 2014- 5.52±0.65, May 2015- 16.79±0.26, *t*=-28.52, d.f.=1, *P*=0.022), but length and width of *F. veroni* and *A. millepora* did not increase significantly (F. veroni: L: Nov. 2014- 6.96 ±1.14, May 2015- 8.80±2.92, *t*=-1.03, d.f.=1, *P*=0.489, W: Nov. 2014- 5.12±0.66, May 2015- 6.67±1.0, *t*=-3.69, d.f.=1, *P*=0.168; *A. millepora*: L: Nov. 2014- 12.71±3.71, May 2015- 14.59±3.10, *t*=-3.05, d.f.=1, *P*=0.202, W: Nov. 2014- 12.18±3.91, May 2015- 13.06 ±4.55, *t*=-1.37, d.f.=1, *P*=0.400, Fig. 1a,b).

At Lamai reef, *F. veroni* length increased significantly but width did not increase significantly (L: Nov. 2014- 9.01± 0.12, May 2015- 10.82±0.04, *t*=-22.62, d.f.=1, *P*=0.028, W: Nov. 2014- 7.51±0.95, May 2015- 9.12±0.39, *t*=-2.69, d.f.=1, *P*=0.226). *A. millepora* and *P. decussata* length and width increased significantly (*A. millepora*: L: Nov. 2014- 10.81±0.54, May 2015- 14.85 ±0.86, *t*=-5.79, d.f.=18, *P*=0.000, W: Nov. 2014- 6.71±0.60, May 2015- 9.39±0.88, *t*= -5.09, d.f.=18, *P*=0.000; *P. decussate*: L: Nov. 2014- 11.90±0.95, May 2015- 16.31±1.35, *t*=-4.48, d.f.=8, *P*=0.002, W: Nov. 2014- 8.03 ±1.04, May 2015- 10.48±1.00, *t*=-4.28, d.f.= 8, *P*=0.003, Fig. 1c,d).

At Hua Thanon reef, *F. fungites* and *A. millepora* length and width increased significantly (*F. fungites*: L: Nov. 2014- 7.26± 0.83, May 2015- 8.29±0.94, *t*=-5.32, d.f.=9, *P*=0.000, W: Nov. 2014- 6.55±0.74, May 2015- 7.70±0.91, *t*=-4.72, d.f.=9, *P*=0.001; *A. millepora*: L: Nov. 2014- 10.66±1.30, May 2015- 14.49±1.77, *t*=-4.93, d.f.=8, *P*=

0.001, W: Nov. 2014- 8.32±1.49, May 2015 - 12.01±2.11, *t*=-4.03, d.f.=8, *P*=0.004), but length and width of *F. varoni* did not increase significantly (L: Nov. 2014- 9.12± 4.31, May 2015- 14.27±3.44, *t*=-5.96, d.f.=1, *P*=0.106, W: Nov. 2014- 7.71±3.40, May 2015- 12.29±2.52, *t*=-5.20, d.f.=1, *P*=0.121, Fig. 1e,f).

At Nathon reef, *P. lutea* length increased significantly but width did not increase (L: Nov. 2014- 9.87±0.67, May 2015- 12.55±1.10, *t*=-3.47, d.f.=10, *P*=0.006, W: Nov. 2014- 7.16±0.52, May 2015- 8.45± 0.82, *t*=-1.67, d.f.=10, *P*=0.125), while both length and width of *F. fungites* increased significantly (L: Nov. 2014- 11.12±0.61, May 2015- 12.29±0.83, *t*=-4.06, d.f.=15, *P*=0.001, W: Nov. 2014- 10.28±0.49, May 2015- 11.10 ±0.61, *t*=-4.03, d.f.=15, *P*=0.001, Fig. 1g,h).

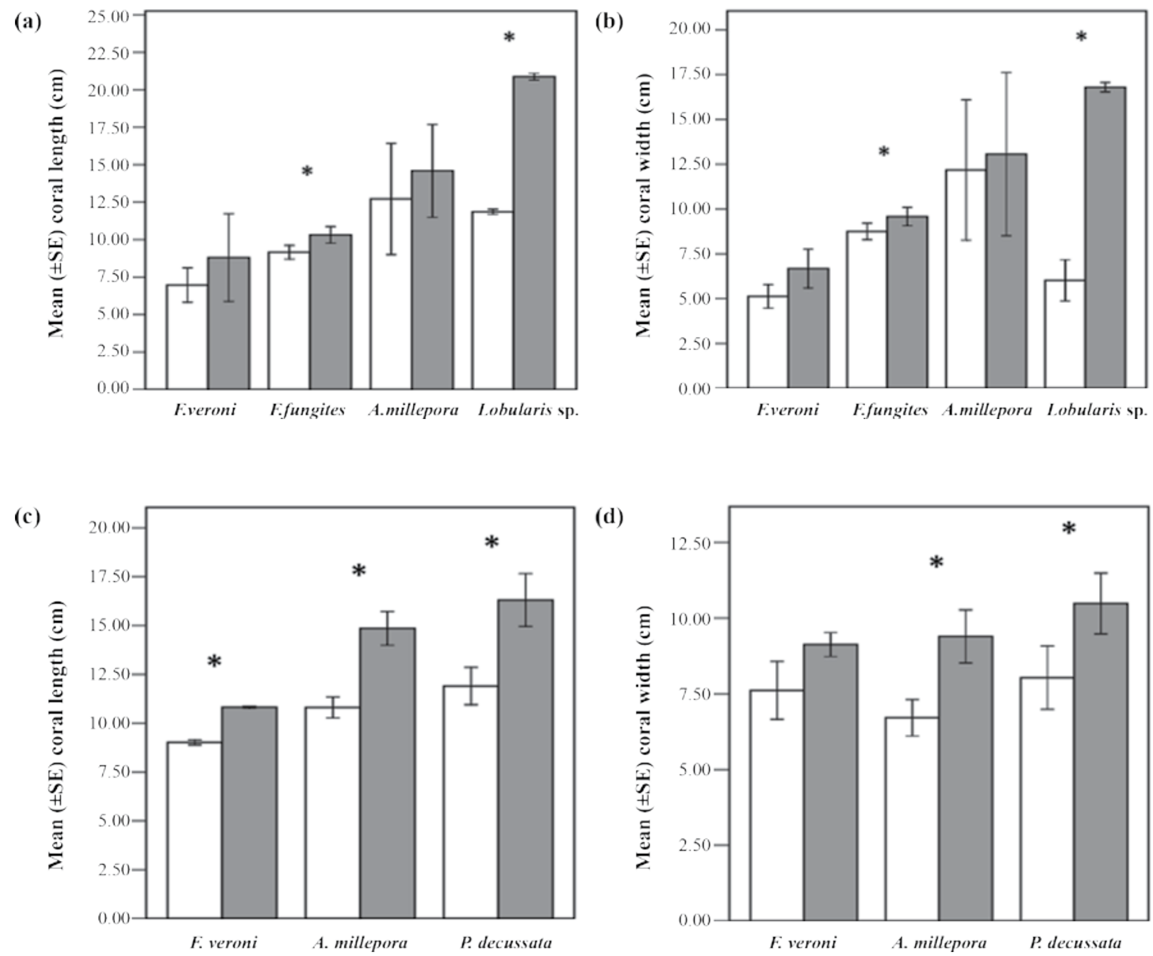

Figure 1. Coral length and width at four sites. (a, b) Maenam, (c, d) Lamai, (e, f) Hua Thanon, and (g, h) Nathon from November, 2014 (white bar) to May, 2015 (gray bar); ‘*’means significant differences between years.

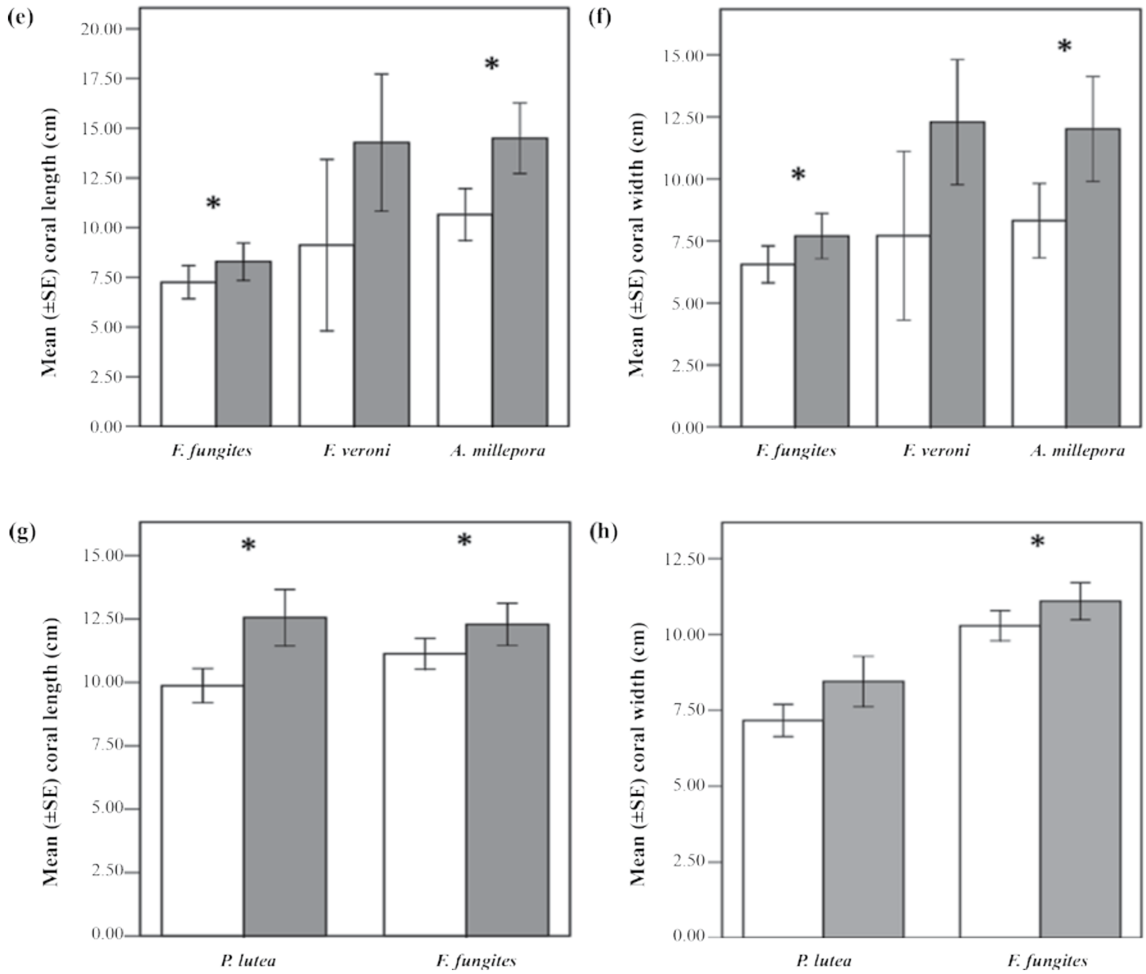

Figure 1. continued. Coral length and width at four sites. (a, b) Maenam, (c, d) Lamai, (e, f) Hua Thanon, and (g, h) Nathon from November, 2014 (white bar) to May, 2015 (gray bar); '*'means significant differences between years.

Coral growth among sites and species

Both sites and species had effects on coral length and width growth (sites: Wilks' Lambda = 0.859, F=2.26, d.f.=6,172, P=0.039; species: Wilks' Lambda = 0.539, F=6.23, d.f.=10,172, P=0.000). Sites had effect on coral width increment but not on coral length increment (width: F=3.05, d.f. =3, P=0.033; length: F=1.64, d.f.=3, P= 0.184) but species had effect on both coral length and width increments (length: F=7.6, d.f.=5, P=0.000; width: F=12.79, d.f.=5, P=0.000). When comparing among sites, post Hoc Tukey showed that coral length was significantly higher at Lamai than at Nathon and Maenam, and coral width was higher at Lamai than at Nathon (Fig. 2a,b). When comparing among species, post Hoc Tukey showed *Lobularis* sp. length and width were significantly higher than other coral species (Fig. 2 c,d).

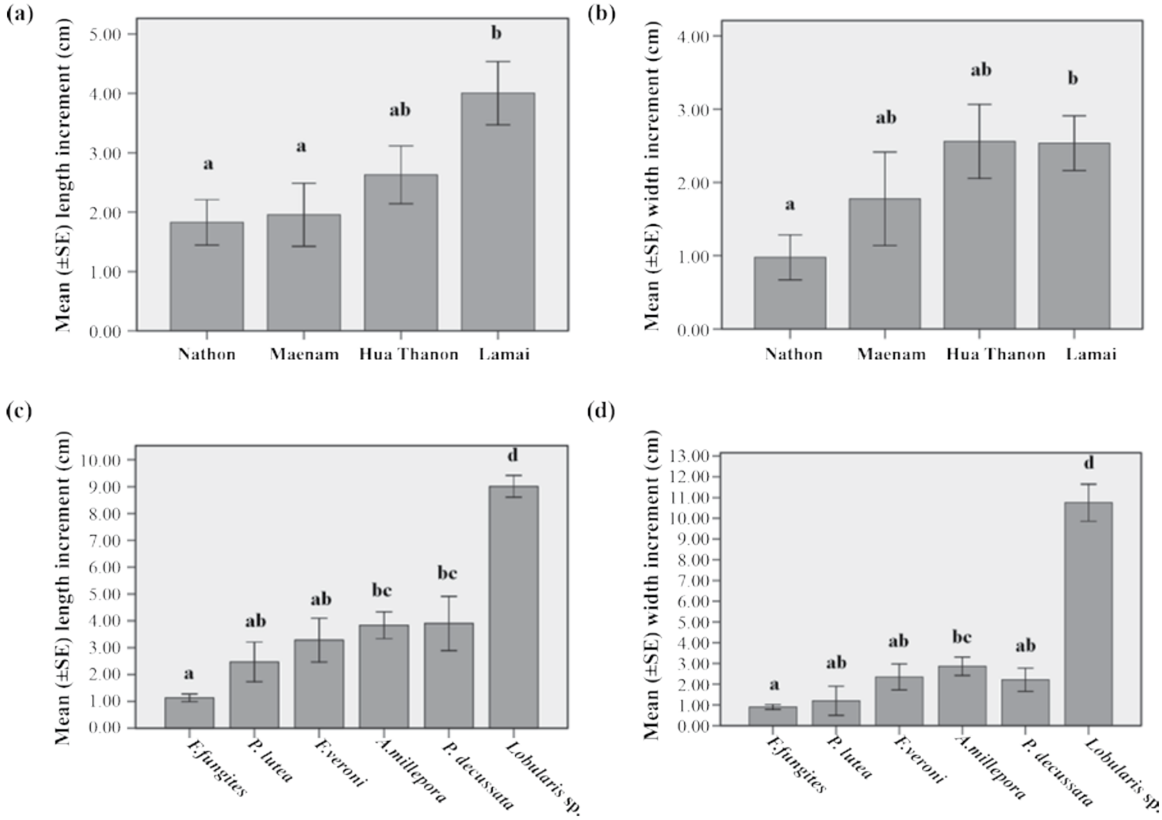

Figure 2. Coral growth, sites and species: (a) and (b) coral length and width increments, respectively, among four sites; (c) and (d) coral length and width increments, respectively, among species. Different letters indicate significant differences.

DISCUSSION AND CONCLUSION

Few studies in Thailand observed that restored *Acropora formosa* and *Porites lutea* in Andaman coast of Thailand survived and grew nicely, although their recovery depended on various environmental factors (Thongtham *et al*., 2003). Our results showed that *Acropora millepora* at reef sites at Samui Island grew ranging from 7.38-8.08 cm•yr^{-1}. This growth rate at Samui Island was within the same range as transplanted *Acropora* sp. at Krok Island, Thailand (Sirirattanachai, 1994; Sirirattanachai *et al*., 1994). The growth rate of the transplanted *Acropora* sp. at Krok Island ranged from 6-10 cm•yr^{-1} and after 12 months, the growth rate of transplanted *Acropora* sp. was still about 6.5 cm•yr^{-1} (Sirirattanachai, 1994; Sirirattanachai *et al*., 1994).

Our results showed that *Porites lutea* was one of the dominant species at Nathon reef that was the most impact from coastal activities and boat transportation with a high sedimentation rate. There could be because *Porites lutea* is able to tolerate sediment deposition through mucous secretion, trapping and subsequent sloughing (Dikou and van Woesik, 2006) and can rapidly regenerate tissue damage (Brown *et al*., 1990; van Woesik, 1998).

Our results clearly showed that Nathon reefs had the lowest coral growth rate among four study sites. There are two possible reasons. First, Nathon reefs faces the most impact from coastal activities and boat transportation with a high sedimentation rate. Second, Nathon reefs are mostly covered by macroaglae such as *Sargassum oligocystum*, *Turbinaria decurrens* and *Dictyota cevicornis* (Yeemin *et al*., 2009). Sedimentation, nutrient enrichment and turbidity can degrade coral reefs on a local scale (Fabricius, 2005) by reducing growth and survival of corals from many taxa. Elevated sedimentation rates from coastal erosion and tourism activities have damaged near shore shallow coral communities (Rogers, 1990; McClanahan and Obura, 1997). Sedimentation rates can damage exposed coral tissue, reduce photosynthesis rates in corals, and inhibit coral recovery (Riegl and Branch, 1995; Philipp and Fabricius, 2003). Near shore coral communities may shift to sediment tolerant coral species (Sofonia and Anthony, 2008).

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