Draft version December 3, 2023
Preprint typeset using LaTeX style emulateapj v. 12/16/11

DIFFERENCE IN COLOR PROFILES BETWEEN LOWER AND UPPER CLASS GALAXIES: EVIDENCE FOR OUTSIDE-IN QUENCHING

Hui Hong[1,2], Huiyuan Wang[1,2], H.J. Mo[3]

Draft version December 3, 2023

ABSTRACT

Subject headings: galaxies: halos - galaxies: general – methods: observational - methods: statistical

1. RESULTS

We use the photometric images taken from SDSS to study color difference between satellite and central galaxies to study the quenching of satellite galaxies. We make control sample to make the corresponding satellites have the same stellar mass and redshift distribution as centrals have. Satellite galaxies are divided into 'upper class' and 'lower class' according to Li et al. (2020). We also divide galaxies into star-forming (SFGs), transition (TGs), quenched (QGs) which are above the blue dashed line, between the blue and red dashed lines, below the red line in Figure 1.

Compared to central and upper class galaxies, there are excess low-mass quenched population for lower class galaxies in Figure 2.

Figure 7 shows the color difference between lower class and central galaxies. Columns from left to right are SF, T, Q galaxies. Rows from top to bottom are different B/T bins. Galaxies of different stellar mass bins are shown in different colors in each panel. Lower class galaxies are on average redder than central galaxies. The color difference for TGs is the largest since TGs are on their way to quenching. Color difference is increasing as radius increases implying the 'outside-in' quenching mode for lower class satellite galaxies. Similar color difference has also been seen for upper class in Figure 8 while the difference is much smaller than that for lower class as upper class galaxies are less affected by environment process. We have also test the color difference derived from sersic profiles which are corrected for PSF effects in Figure 12 and 13. Our results remain the same.

We check the mass surface density profiles in Figure 9 and 10 for different stellar mass bins. As we can see that there is no obvious difference in mass surface density between lower class, upper class and central galaxies. This may imply that the quenching process operated on the outskirts of satellite galaxies cannot affect the stars, thus exclude tidal stripping and favor the ram-pressure stripping which can only strip the gas.

We have also check the difference of lower class galaxies with different halo-centric distance and halo mass in Figure 11. Lower class living in the center of halos and massive halos are redder especially for transition galaxies implying dense environment can quench galaxies in more violent manner.

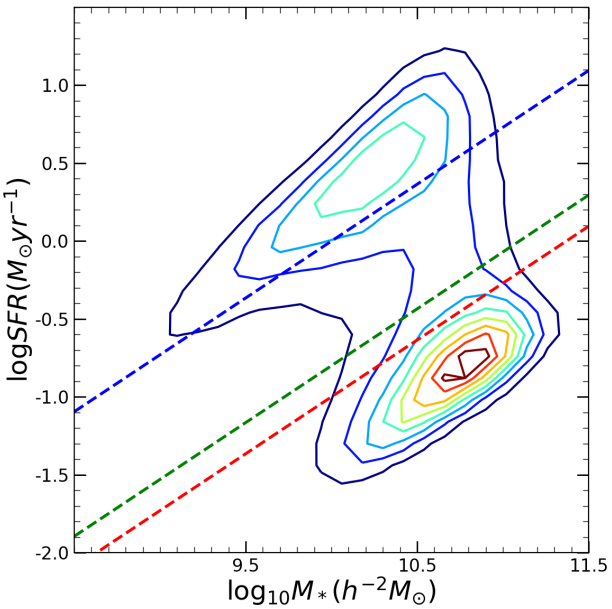

FIG. 1.— SFR as a function of stellar mass. The demarcation lines: $\log_{10}$SFR=0.73$\log_{10} M_*(h^{-2}\mathrm{M}_\odot)-1.46\log_{10} h$+$A$, A_{blue}=-7.5, A_{green}=-8.3, A_{red}=-8.5. Galaxies above the blue dashed line are divided into star-forming galaxies, between the blue and the red dashed lines are transition galaxies and below the red one are quiescent galaxies. Colors from blue to red of the contours correspond to the increasing contour levels. Here galaxies are not weighted.

[1] Key Laboratory for Research in Galaxies and Cosmology, Department of Astronomy, University of Science and Technology of China, Hefei, Anhui 230026, China
[2] School of Astronomy and Space Science, University of Science and Technology of China, Hefei 230026, China
[3] Department of Astronomy, University of Massachusetts, Amherst MA 01003-9305, USA

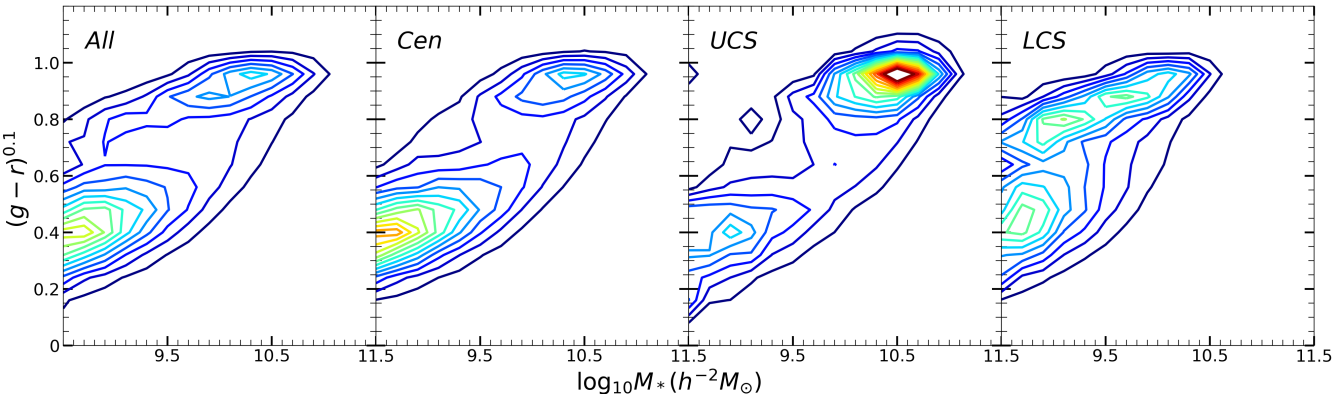

FIG. 2.— Panels from left to right are the $(g-r)^{0.1}$-M_* diagrams of all galaxies, Cen (central galaxies), UCS (upper class satellite galaxies) and LCS (lower class satellite galaxies). Colors from blue to red correspond to increasing contour level. Each galaxy is weighted here.

REFERENCES

Li, P., Wang, H., Mo, H. J., Wang, E., & Hong, H. 2020, ApJ, 902, 75

APPENDIX

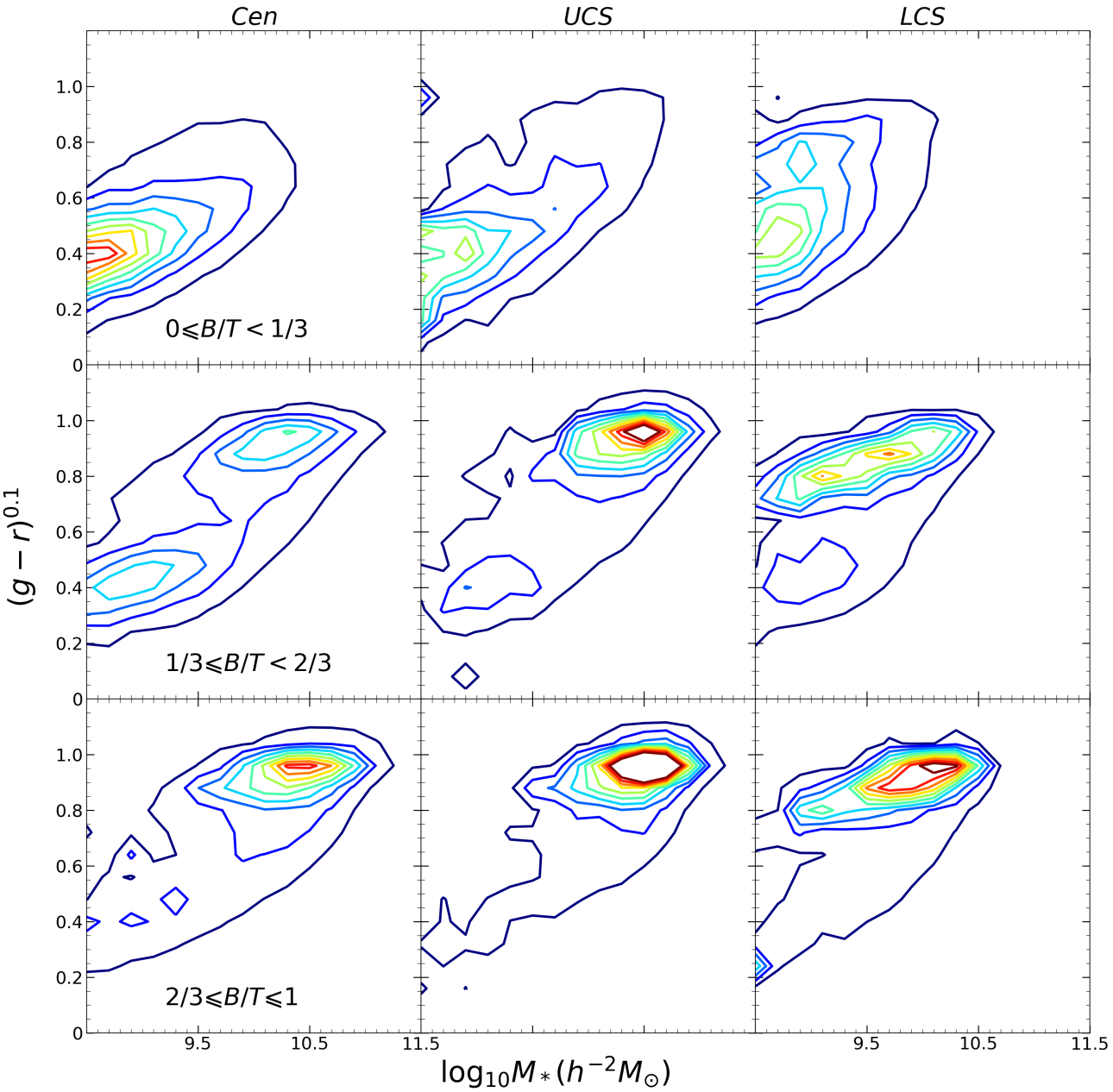

FIG. 3.— Similar to 2. Columns from left to right are the $(g-r)^{0.1}$-M_* diagrams of Cen (central galaxies), UCS (upper class satellite galaxies) and LCS (lower class satellite galaxies). Rows from top to bottom correspond to different B/T bins: $0 \leqslant B/T < 1/3$, $1/3 \leqslant B/T < 2/3$, $2/3 \leqslant B/T \leqslant 1$.

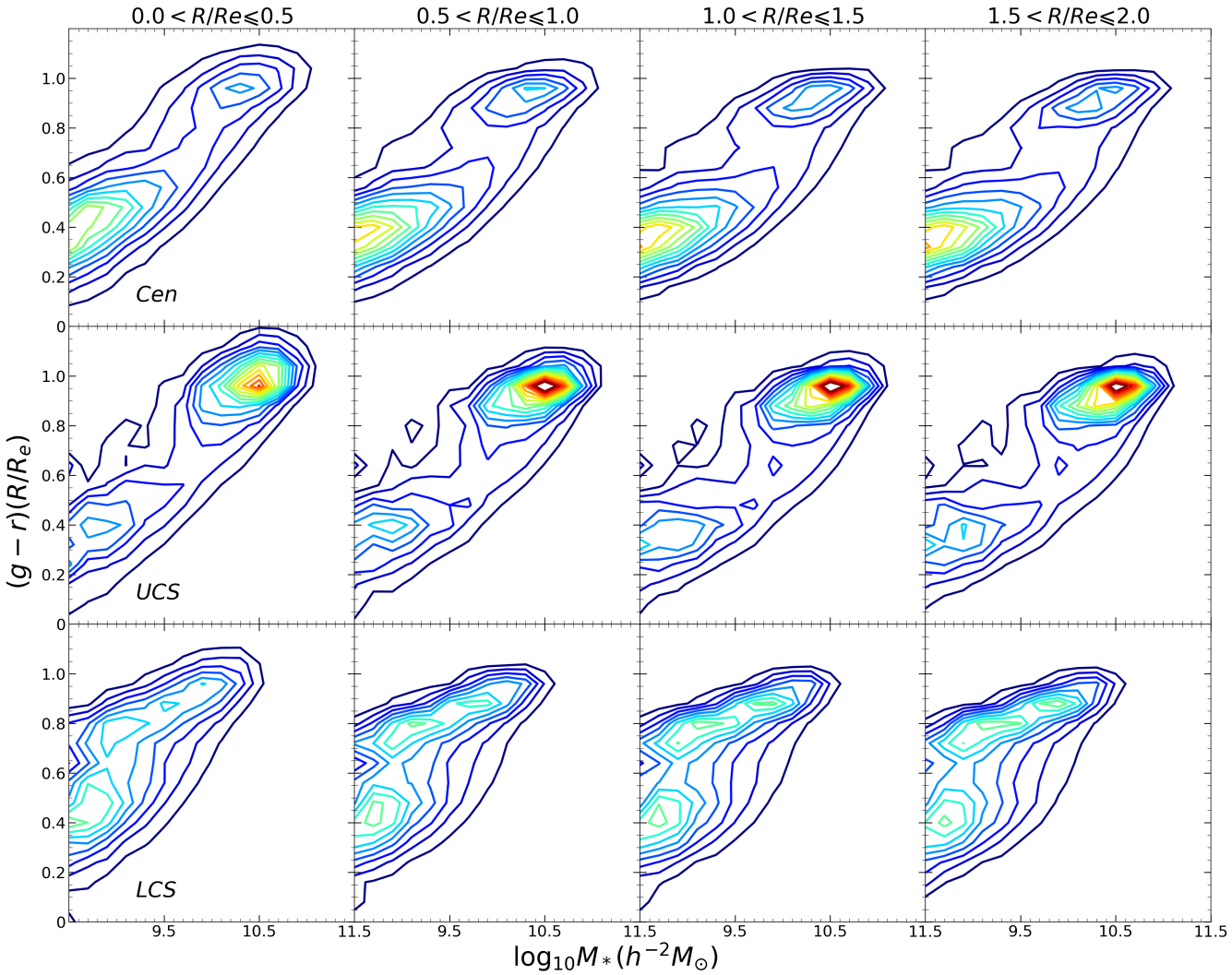

FIG. 4.— (g − r)(R/R$_e$)-M_* diagrams. Rows from top to bottom are for Cen, UCS and LCS galaxies. Columns from left to right are (g − r)(R/R$_e$) calculated in different annuli: $R/R_e \leq 0.5$, $0.5 < R/R_e \leq 1.0$, $1.0 < R/R_e \leq 1.5$ and $1.5 < R/R_e \leq 2.0$.We have each galaxy weighted here. For the lower-class galaxies, we can see clearly, there are two components for the quiescent galaxies. It is particularly significant at the outer region.

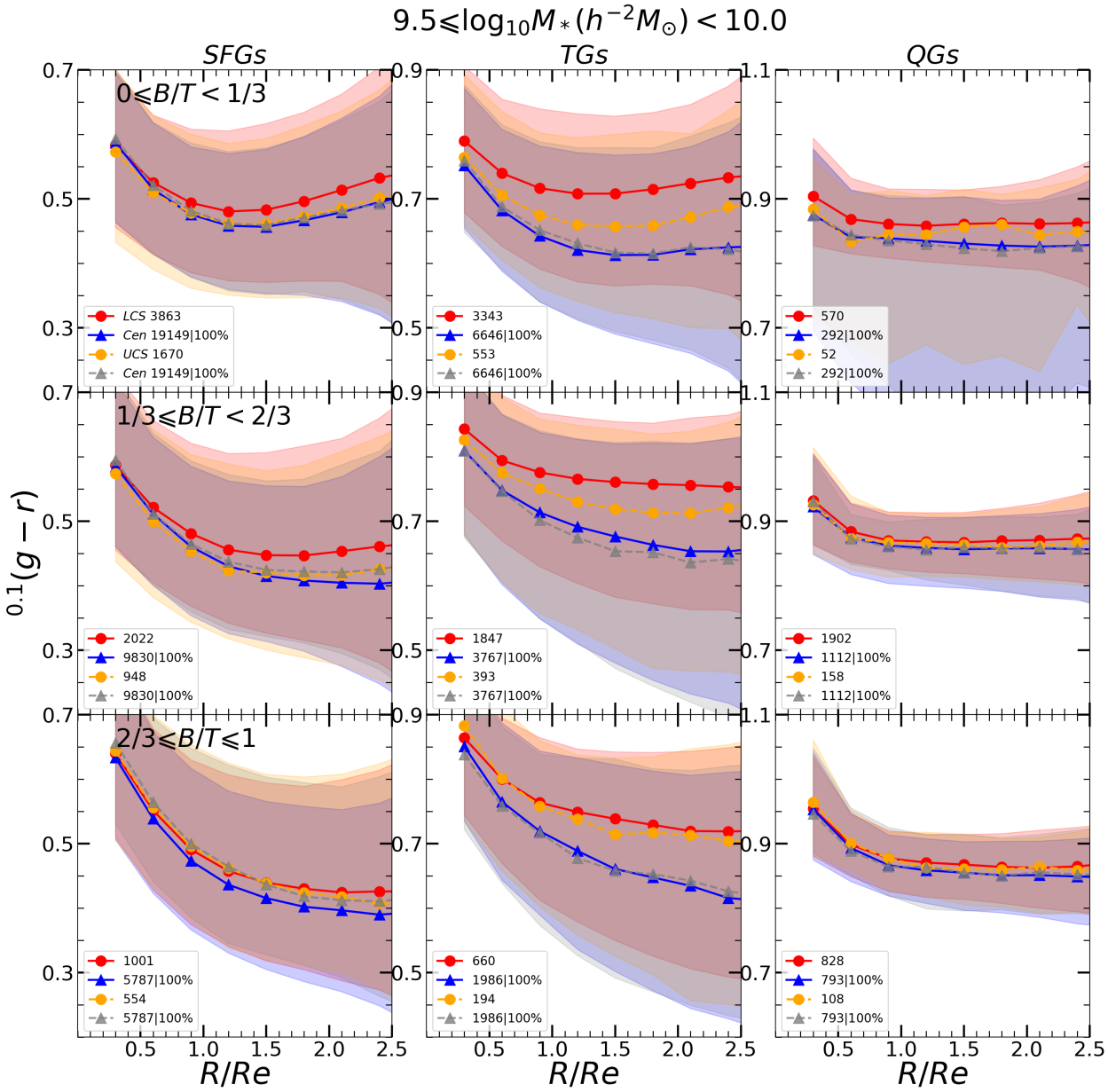

FIG. 5.— The median (g − r) as a function of R/R_e of galaxies of $9.5 \leq \log M_*/h^{-2}\mathrm{M}_\odot < 10.0$. The results of central-lower class satellite pairs are shown in solid lines as indicated and that of the central-upper class satellite pairs are shown in dashed lines. The number of each type of galaxies together with the percent of the matched central galaxies is labeled. Three rows from top to bottom: $0 \leq B/T_\mathrm{m} < 1/3$, $1/3 \leq B/T_\mathrm{m} < 2/3$ and $2/3 \leq B/T_\mathrm{m} \leq 1$. Three columns from left to right shows the results of blue clouds galaxies, green valley galaxies and red sequence galaxies. Error bars are with 1 σ error. If a bin with galaxy number below 50, we ignore it. **here, perhaps, we should show the results for** $9.0 \leq \log M_*/h^{-2}\mathrm{M}_\odot < 9.5$

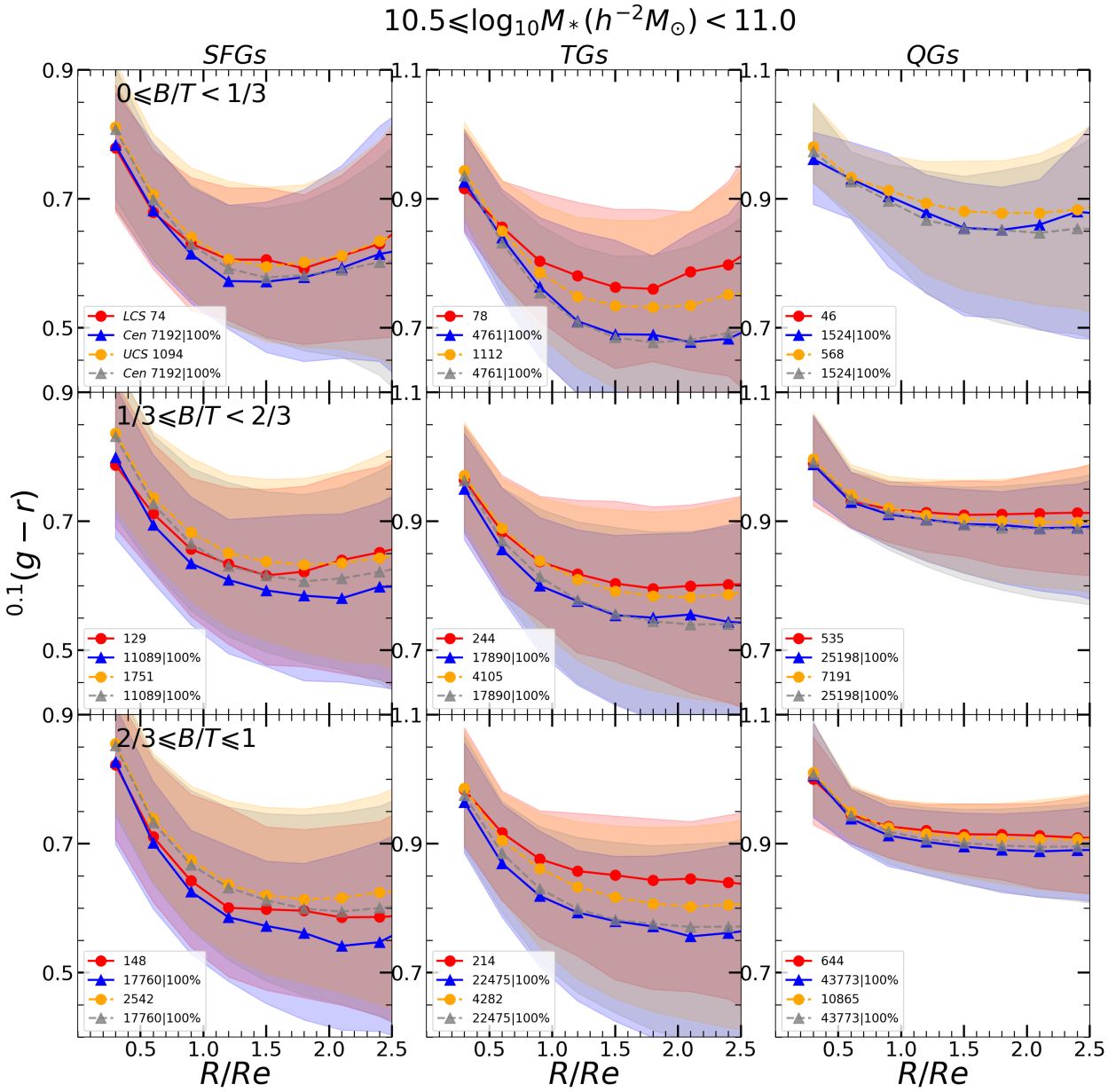

FIG. 6.— Similar to Figure 5,but for $10.5 \leq \log M_*/\,h^{-2}\mathrm{M}_\odot < 11.0$

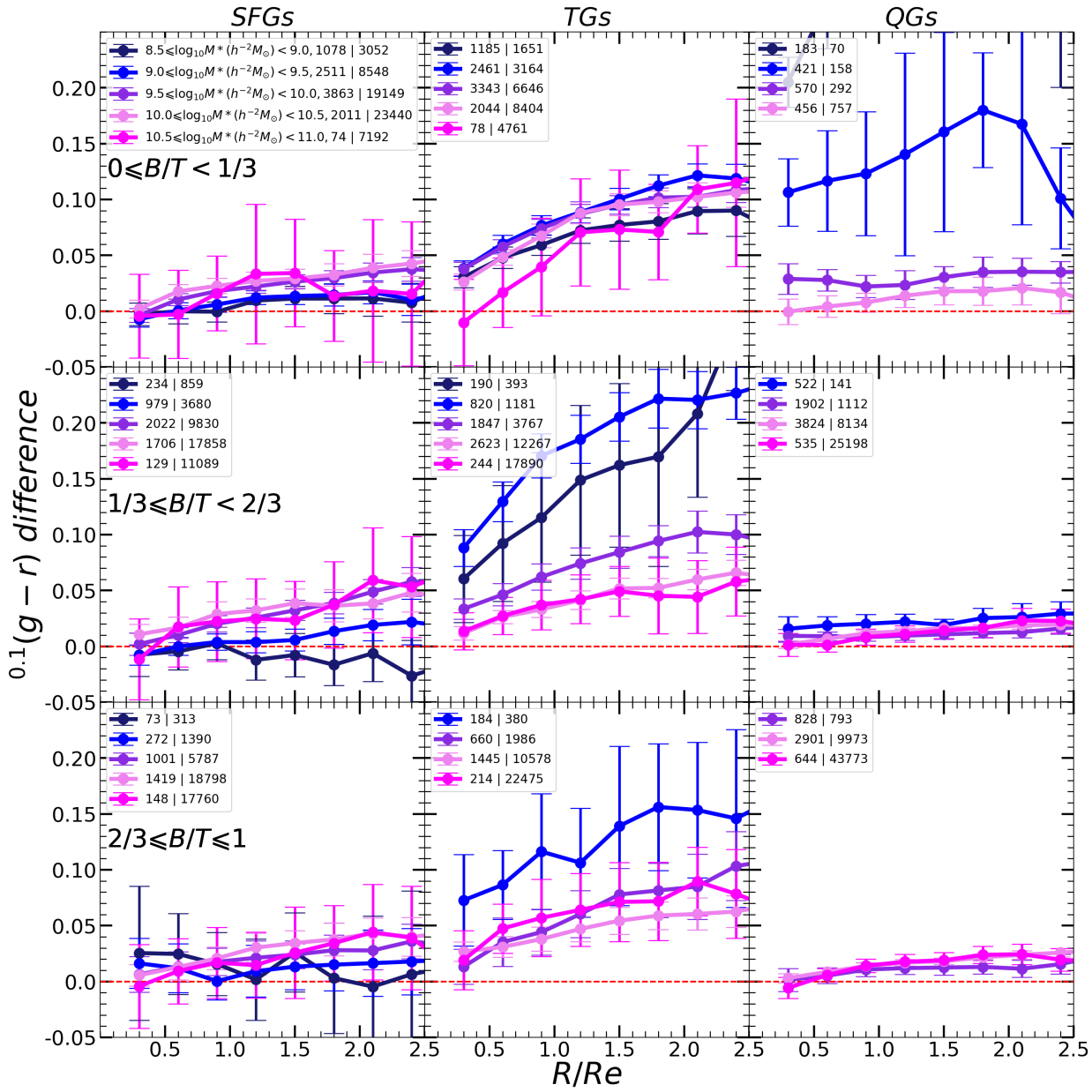

FIG. 7.— Color difference of central-lower class satellite pairs as function of $R/R_{\rm e}$. Three rows are for $0 \leq B/T_{\rm m} < 1/3$, $1/3 \leq B/T_{\rm m} < 2/3$ and $2/3 \leq B/T_{\rm m} \leq 1$. Three columns show the results of blue cloud galaxies, green valley galaxies and red sequence galaxies. In each panel, different colors correspond to the results of different M_* and the label shows the number of lower class satellite galaxies and central galaxies from left to right. We ignore the result of a bin if the number of lower class galaxies or central galaxies is below 50.

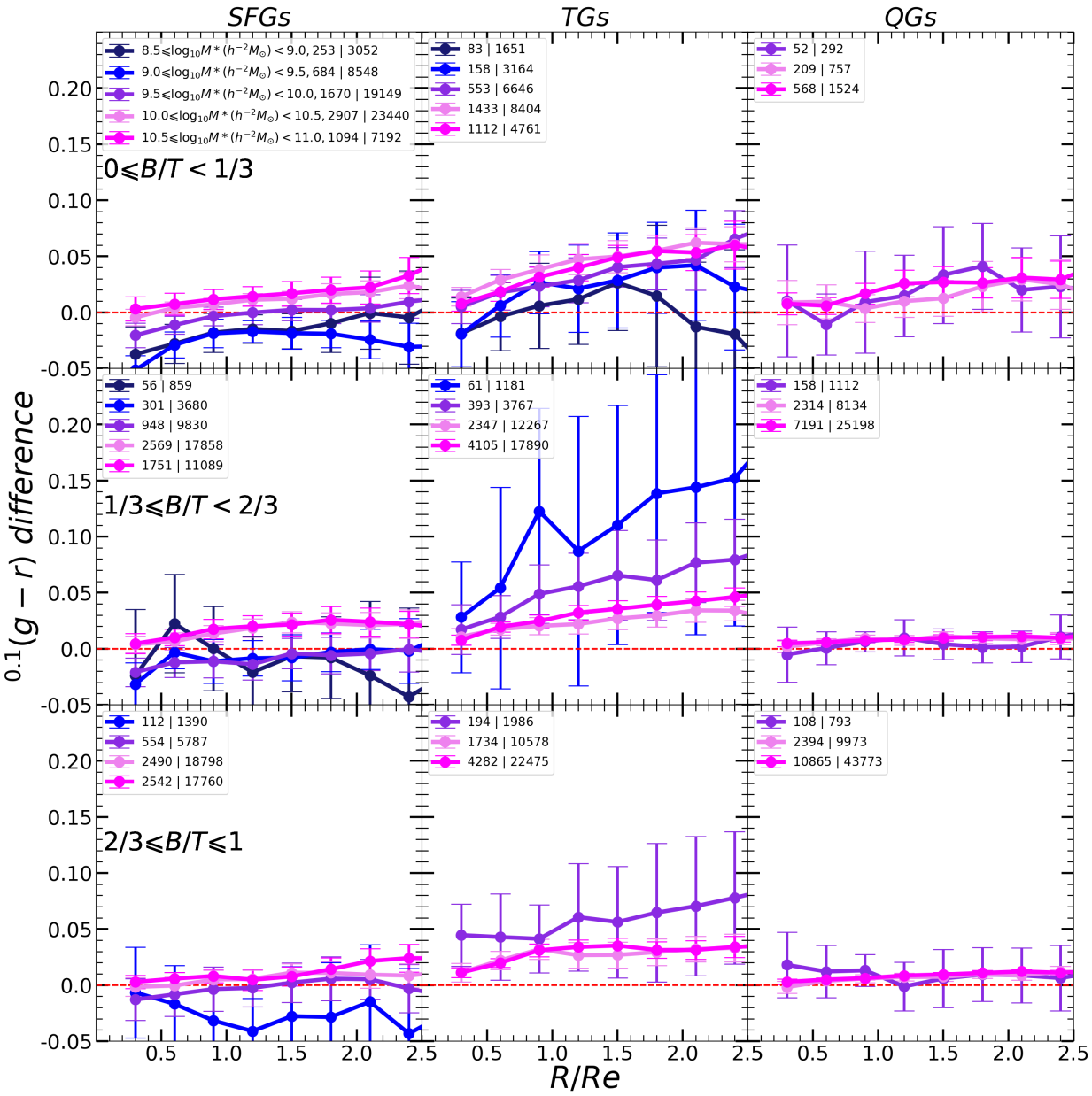

FIG. 8.— Similar to Figure 7, but for the central-upper class satellite pairs.

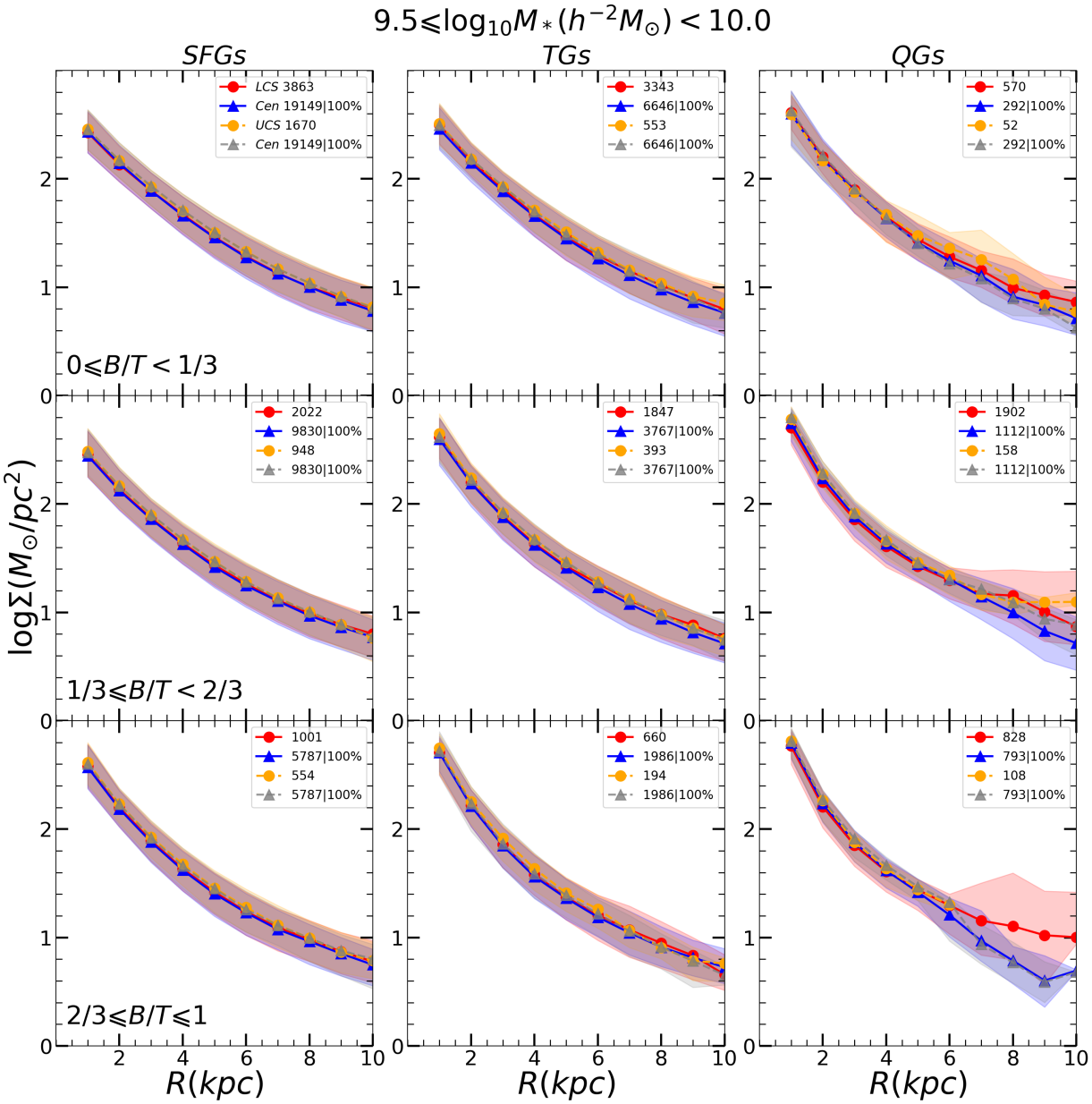

FIG. 9.— Similar to Figure 5,but for the surface mass density as a function of R(kpc) of galaxies of $9.5 < \log M_*/h^{-1}\mathrm{M}_\odot < 10.0$.

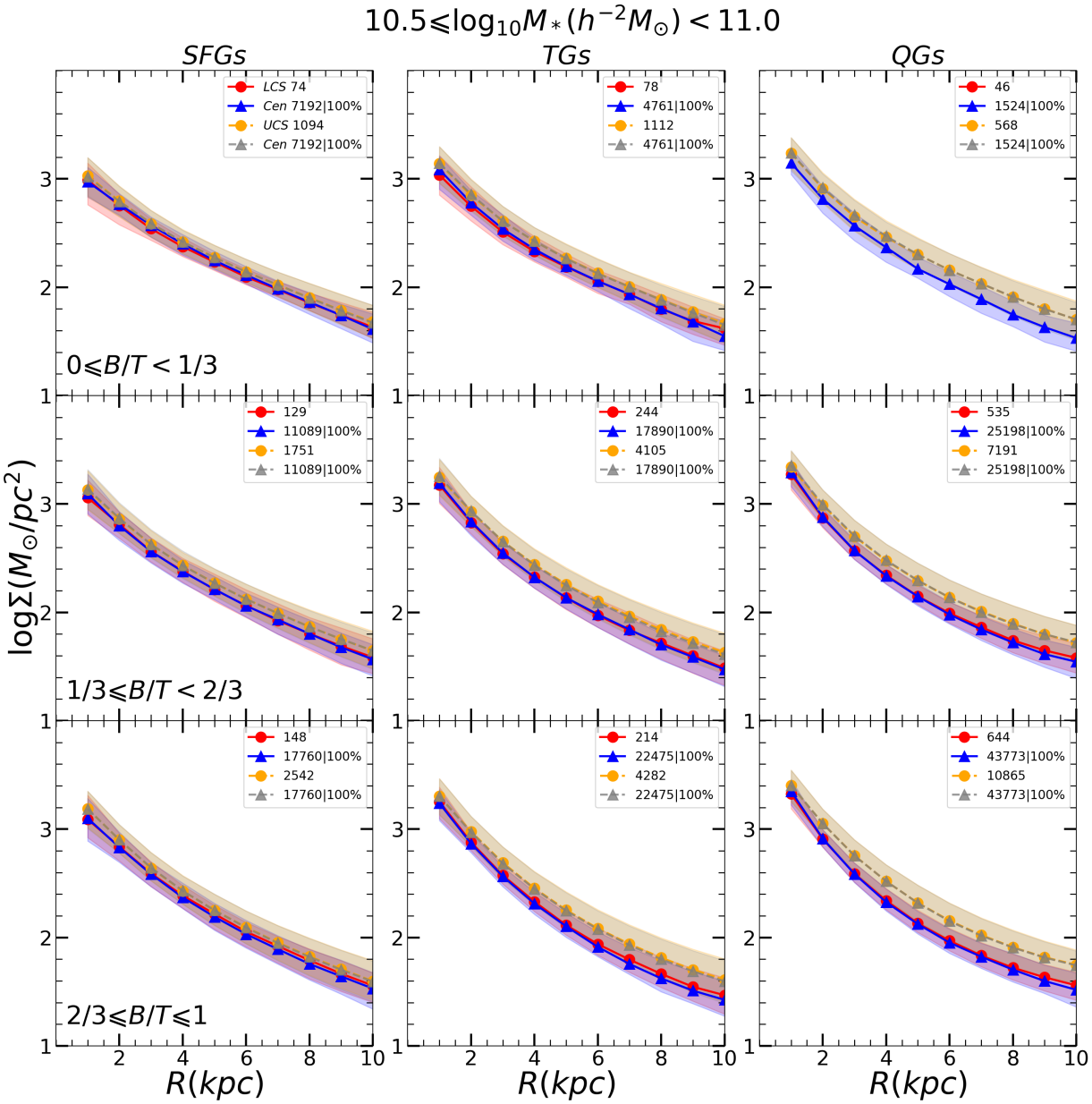

FIG. 10.— Similar to Figure 9, but for $10.5 < \log M_*/h^{-1}\mathrm{M}_\odot < 11.0$.

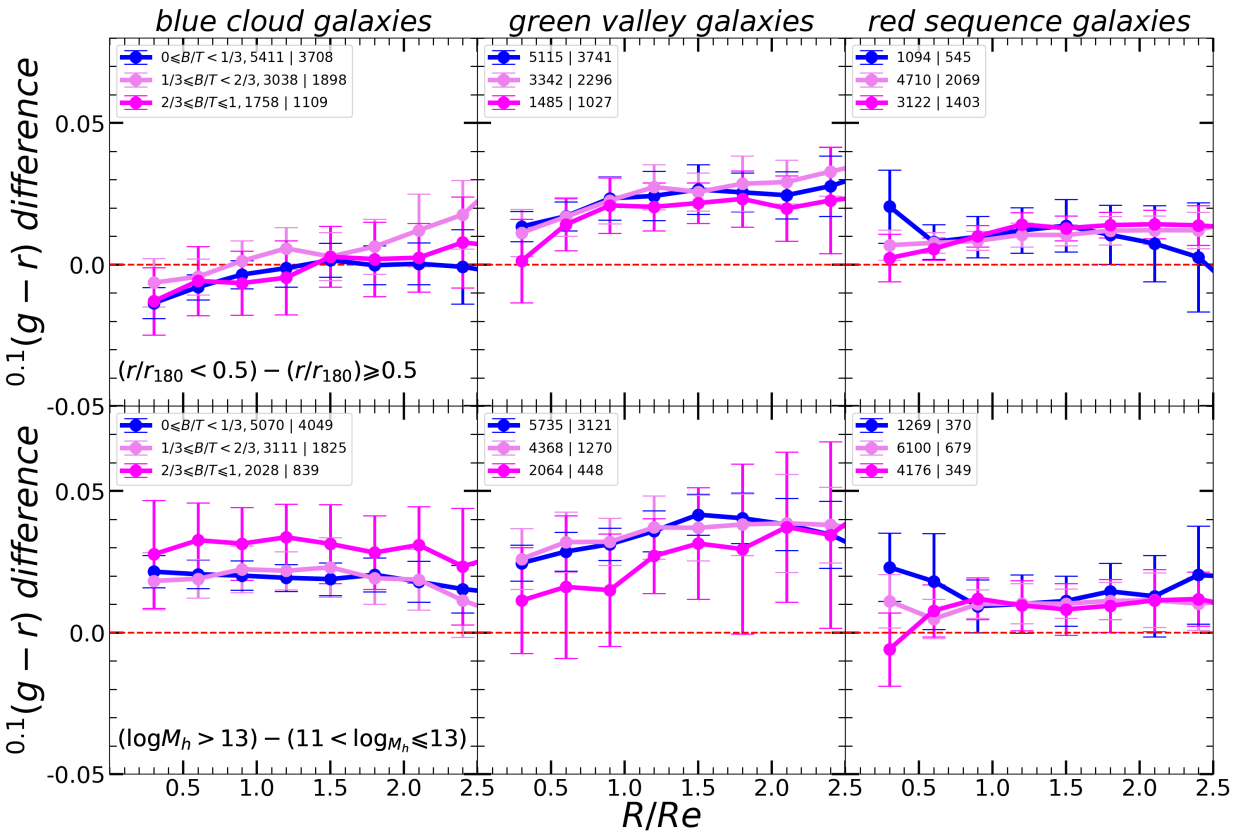

FIG. 11.— Color difference of lower upper class pairs with $r/r_{180} < 0.5$ and $r/r_{180} \geq 0.5$ (top panels), $\log M_{\rm h} > 13$ and $\log M_{\rm h} \leq 13$. Star-forming, transition and quenched galaxies are shown in columns from left to right. Different colors corresponds to different B/T bins.

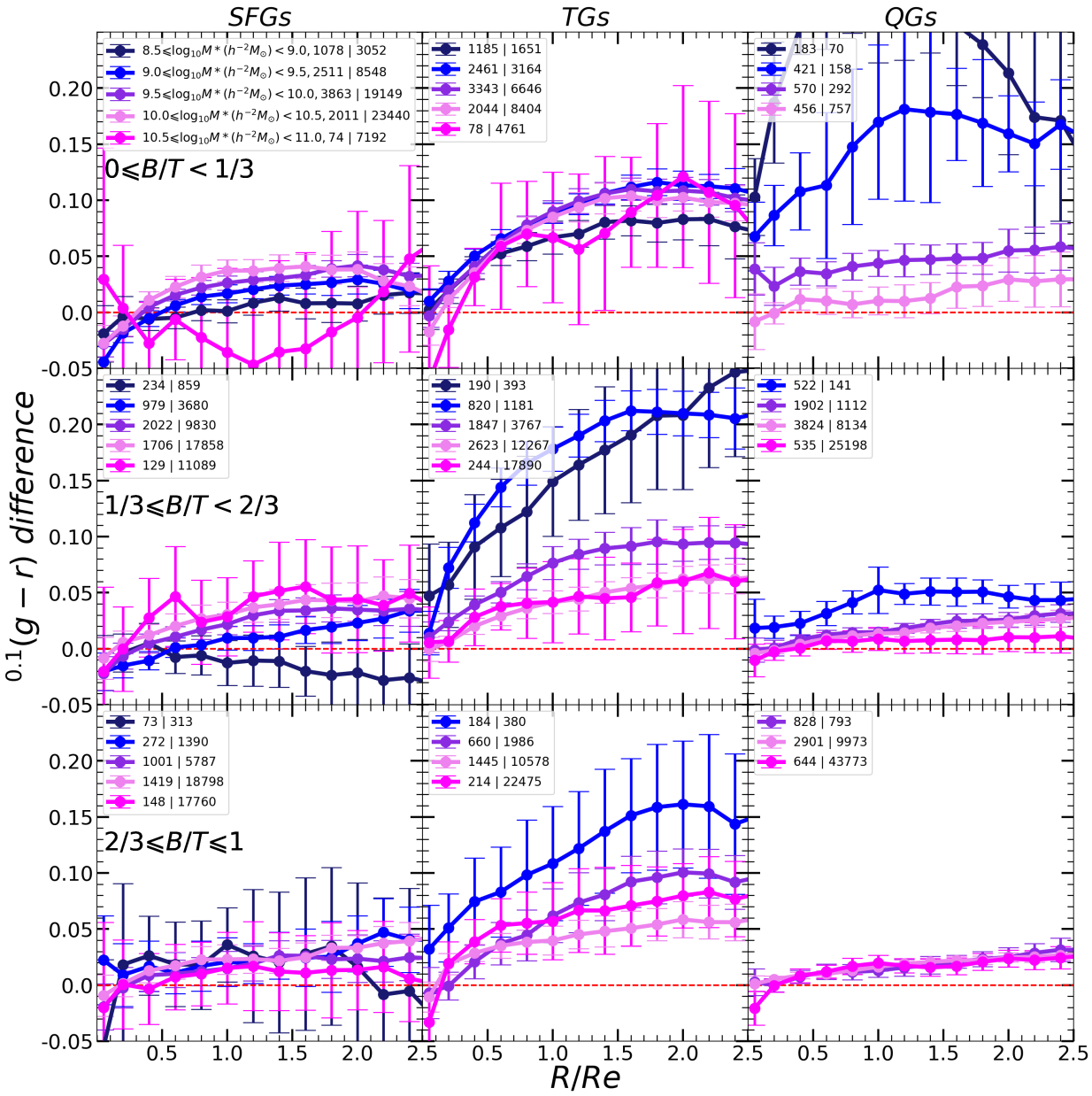

FIG. 12.— Similar to Figure 7, except that the (g − r) is calculated using the Sersic fits profile.

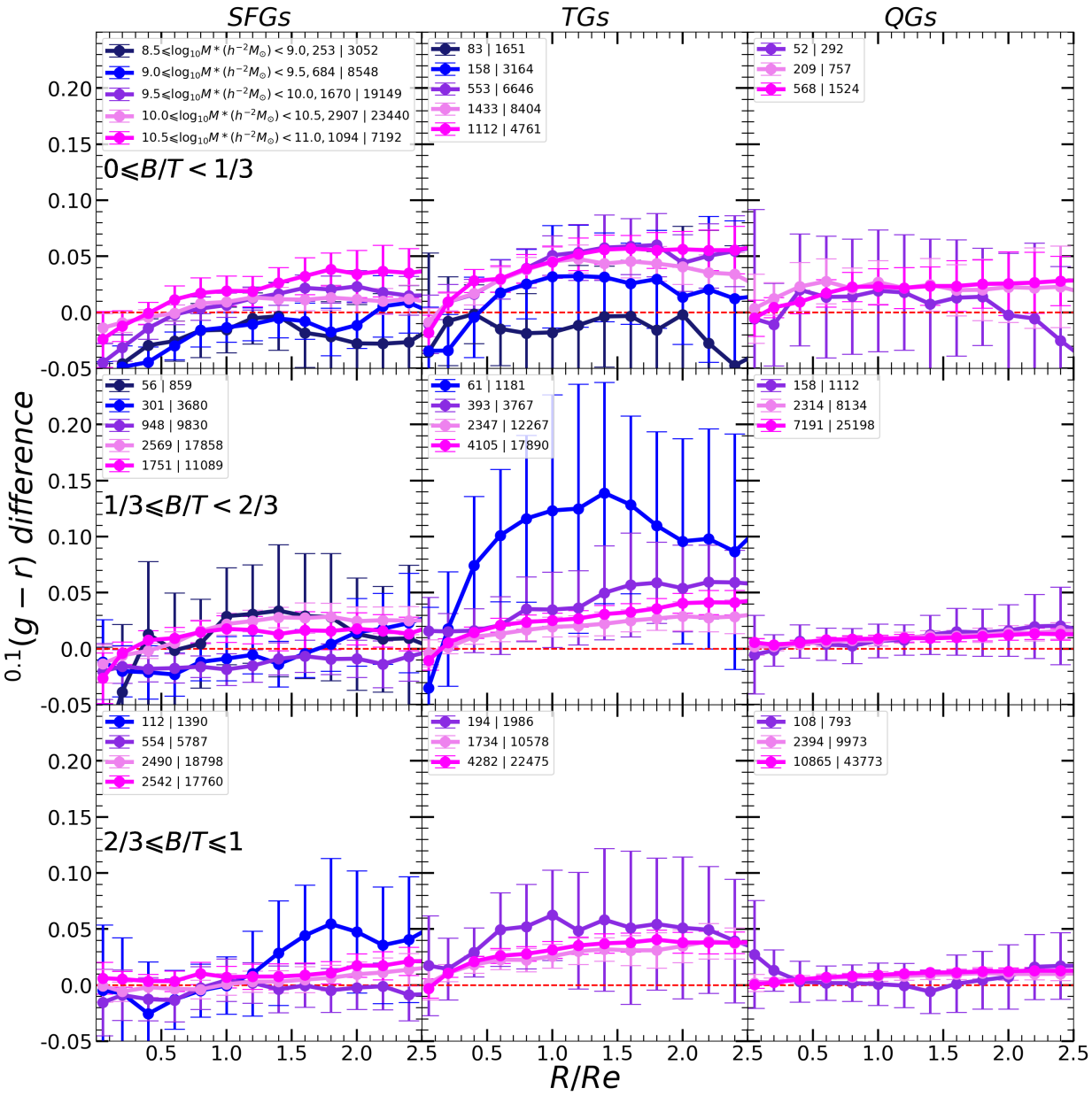

FIG. 13.— Similar to Figure 12 but for the central-upper class satellite pairs.