Seasonal Variations in the Plankton Density at an Urban and a Rural Ponds of Semi Arid Zone of Gujarat

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ABSTRACT

Wetlands, being the transitional zone between land and water are highly productive ecosystems, standing second only to Tropical Rain forest. Only after the realization of their significant role as an ecosystem, studies regarding them as complete ecosystem are initiated with reference to the biodiversity. Urbanization has played a major role in limiting this biodiversity. Out of various parameters that affect the wetland dynamism, the primary producers (Phytoplankton) and the primary consumers (Zooplankton) are the major components affecting the overall state of wetlands. The present study discusses the variations in the plankton density at an urban pond and a rural village pond of semi arid zone of Central Gujarat India. The three groups of plankton studied are Phytoplankton (Group I), Rotifers (Group II) and Crustaceans (Group III). The study reveals the fact that the plankton densities are different at the village pond and the urban pond. It has been observed that seasonal variations at the rural village pond are significantly high as compared to that at the urban pond. Seasonal dominance of the species is also different at the two ponds with Crustaceans dominating both the ponds through out the year whereas rotifers dominating only during post monsoon at rural pond. Effects of eutrophication are discussed.

INTRODUCTION

Wetlands, being the transitional zone between land and water are highly productive ecosystems, standing second only to Tropical Rain forest. Only after the realization of their significant role as an ecosystem, studies on these ecosystems were initiated with reference to the biodiversity. However, the conservation of the wetlands was size specific and only the larger wetlands were considered for the biological and ecological studies and the smaller wetlands are always ignored. The health of any ecosystem is considered on the basis of the communities supported by it. Thus the wetland ecosystem depends upon the aquatic communities that in turn are regulated by the array of biotic and abiotic factors (Mitsch and Gosselink, 1993).

The primary productivity and the biomass availability are the bases of the trophic structure of a community (Vakkilainen *et al.*, 2004). Plankton communities represent important elements of the biota in ponds and that form predominant community (Soininen *et al.*, 2007). Among these the Phytoplankton being the main source of primary productivity serve as the primary producers in this ecosystem. They also occupy an important position in the food web (Rothhaupt, 2000). As the quality of water can easily change the density and the diversity of the plankton the plankton community is considered as ecological health indicator of a wetland (Bary, 1959; Jones, 1968; Lindo, 1991; Webber & Webber, 1998; Webber *et al., 2005;* Padisak *et al.*, 2006). Plankton communities are influenced by not only physical and chemical quality of water but also due to variations in food availability and predation. (Coman *et al.*, 2006).

The increase in the human population has led to the expansion of the city limits and as a result the dependency of humans on the wetlands has increased. This has often turned into the anthropogenic pressures on waterbodies around urban area leading to the change in the physico-chemical characteristics. Seasonal changes also influence chemical composition of water. These changes in turn influences the plankton density and diversity. Here, an attempt has been made to find effect of urban pressures as well as seasonal variations in the density and species richness of plankton.

STUDY AREA

In the semi arid zone of central Gujarat, even before the construction of the major reservoirs, village ponds were present that were constructed for the storage of water. Every village in the area has a pond on its outskirts. Two such ponds were selected in the present study. The first situated in the rural area is the Masar Village Pond (MVP) located at 22° 08' N, 72° 54' E at Masar village of Padra Talluka, District Vadodara. It is about 45 kms. South- West of Vadodara city on Jambusar road. It spreads only in 4 acres. Mahi River estuary in the Gulf of Khambhat is just about 15-18 kms. away from MVP. The Masar village pond almost dries off during summer and water is confined only to certain areas, forming few puddles. This village pond is given on lease for fishing and the fishes are harvested every alternate year. Due to heavy rainfall during monsoon the pond often overflows. No major source of pollution is observed at MVP. The domestic dependency on the village pond is observed in the form of washing of cloths and utensils and the wallowing of cattle.

The other village pond selected *i.e.* the Harni village pond (HVP) is located in the North- East part of Vadodara city (22° 20' N, 72° 84' E). Recently the city limits have been extended beyond HVP as a result of poulation growth. HVP a typical rural wetland which is now very rapidly undergoing urbanization and hence loosing its natural characteristics as well as the area. The area of the pond which was 45 acres in 50s (Pathak, and Satakopan, 1957) had decreased to 20 acres in 1990; (Padate and Sapna, 1996) and now it spreads only in approximately 2 acres. Small industries, small factories and residential societies are rapidly coming up around HVP which is not only covering the pond area but is also increasing the pollution level. The pollution in the form of domestic use as well as sewage input is observed at HVP. A sewage outlet from the neighbouring area directly pours the sewage in the water of HVP. The pond is now thought to be of a nuisance by the locals and they are of a vote to drain the wetland and convert it to land.

MATERIALS AND METHODS

Both the wetlands were visited twice in a month at an interval of about 15 days from March 2005 to March 2007. During each visit the plankton were collected from three selected point of the wetland. At each point fixed volume of water (*i.e.* 10 Liters) was filtered through the net of mesh size 0.05nm (Michael, 1986) into 100ml bottles. The net was then washed with the water by inverting the net to collect plankton attached to the net. The sample was fixed by adding 1 ml of 10 % Formalin and 1 ml of Lugol's Iodine in the collection bottle at the collection point. 10 ml well mixed of sample from each station was further concentrated by centrifuging at 2000 RPM for 10 min. From each sample slides were prepared with one drop (0.05ml) of sample and observed under the low and high powers of microscope. The plankton observed were identified upto the genus/ species level using the standard key by Edmonson (1963). The number of plankton was considered for calculating density.

Three groups of plankton were studied. Group I Phytoplankton, Group II Rotifers and Group III Crustaceans.

The data of 3 months over the 2 years was pooled and analyzed for seasonal variations for winter (December, January, February), Summer (March, April, May), Monsoon (June, July, August) and Post monsoon (September, October, November). Further the Mean, standard error of mean (SEM) and one-way ANOVA with No post test for density and species richness of four seasons and the t test for comparing the plankton attributes of both the ponds was performed using GraphPad Prism version 3.00 for Windows, (GraphPad Software, San Diego California USA).

RESULTS

MVP: The variations in the plankton densities over the seasons at MVP are given in Fig. 1.

Different seasonal variations are observed at two ponds studied. The plankton poulation at Masar village pond is under the influence of natural environmental conditins of the semi arid zone of central Gujarat India.

The seasonal variations at MVP indicate that the total plankton density varies highly significantly ($P < 0.0001$, $F_{3,\,47}$ 8.1), the Crustacean denstiy significantly significantly ($P < 0.001$, $F_{3,\,46}$ 5.5), Rotifers significantly ($P < 0.05$, $F_{3,\,38}$ 3.6) and Phytoplankton insignificantly ($P > 0.05$, $F_{3,10}$ 1.1) (Fig. 1) over the year. The total plankton density was highest during summer (7146.0 + 1363.0/l) and lowest during monsoon (911.1 + 396.6/l) while during postmonsoon it was 3100.0 + 759.4/l and

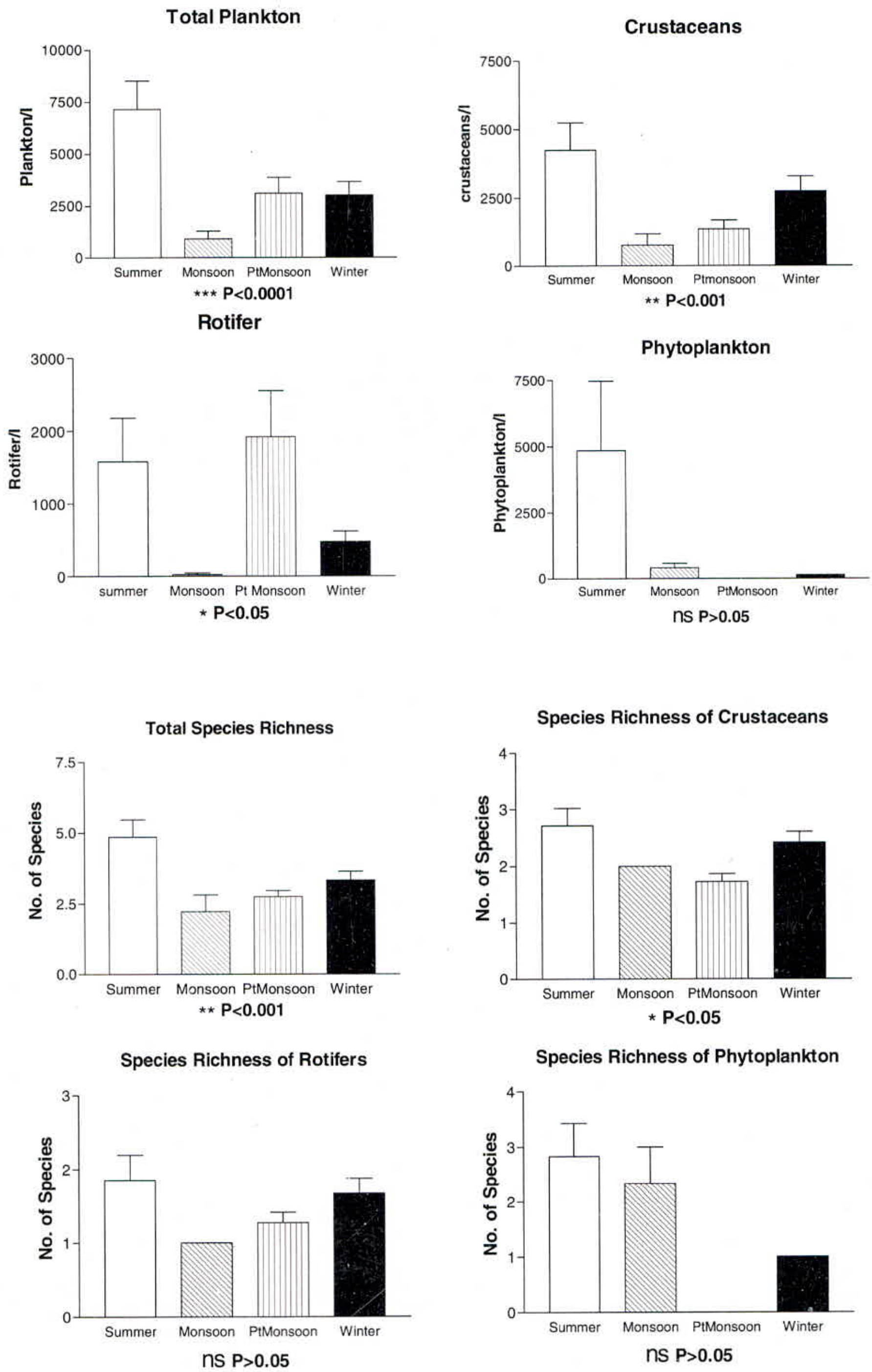

Fig. 1: The variation in the plankton density and species richness over the four seasons from March 2005 to March 2007 at MVP

during winter it was 3022.0 + 632/l. The Crustacean density was highest during summer (4228.0 + 1004.0/l) and lowest during monsoon (755.5 + 414.3/l) while during postmonsoon and winter it was 1344.0 + 329/l and 2722.0 + 551.3/l respectively. At MVP Rotifer density was minimum during monsoon (22.22 + 22.22/l) and maximum during postmonsoon with 1915.0 + 632.9/l. The density declined during winter 476.2 + 139.1/l and increased during summer (1578.0 + 598.0/l). The phytoplankton has a different distribution pattern, where the maximum density was noted during summer (4844.0 + 2630.0/l) followed by monsoon (400.0 + 172.1 /l) and it was completely absent in postmonsoon and appeared only once during winter (133.3 + 0.0 /l).

When the species richness is considered, the total plankton species richness showed significantly significant variations ($P < 0.001$, $F_{3\ 43}$ 6.0) across the seasons. The Crustacean species richness varied significantly across the season ($P < 0.05$, $F_{3\ 39}$ 3.6) whereas the Rotifers ($P > 0.05$, $F_{3\ 22}$ 2.9) and phytoplankton ($P > 0.05$, $F_{3\ 9}$ 3.9) varied insignificantly. The total species richness was highest during summer (4.9 + 0.6) and lowest during monsoon (2.2 + 0.6) while during postmonsoon and winter it was 2.75 + 0.2 and 3.31 + 0.3 respectively.

HVP: *The variations in the plankton densities over the seasons at HVP are given in Fig. 2.*

At HVP the overall total plankton density showed significant variation ($P<0.05$, $F_{3,\ 47}$ 4.1) over the seasons, however, the densities of groups varied insignificantly with the Crustacean density $P > 0.05$, $F_{3,47}$ 2.2, Rotifer density $P > 0.05$, $F_{3,\ 7}$ 1.3 and Phytoplankton density $P > 0.05$, $F_{3,\ 16}$ 1.8. Though insignificant the total plankton and Crustacean densities followed parallel trends with highest density 5362.0 + 1219.0/l and 3448.0 + 836.6/l, during summer and lowest 2056.0 + 392.3/l and 1622.0 + 346.9/l during monsoon respectively. During postmonsoon and winter the total plankton densities were 2289.0 + 514.3/l and 3733.0 + 377.1/l and Crustacean densities were 2178.0 + 493.0/l and 3128.0 + 280.7/l respectively. At HVP the Rotifer denstiy was highest during monsoon (1067.0 + 266.7/l) while they were absent during winter. The density during summer and postmonsoon were 613.3 + 293.9/l and 400.0 + 266.7/l respectively. The Phytoplankton density was also highest during summer (2967.0 + 784.7/l), while minimum during postmonsoon (177.8 + 44.44/l). During monsoon it was 511.1 + 176.9/l and during winter 2622.0 + 1957.0l/l.

The total plankton ($P > 0.05$, $F_{3,\ 45}$ 2.2) and the phytoplankton ($P > 0.05$, $F_{3,\ 15}$ 0.4) species richness showed insignificant variations while Crustaceans showed significant ($P < 0.05$, $F_{3,\ 42}$ 3.9) and Rotifers highly significant ($P < 0.0001$, $F_{3,\ 7}$ 20.5) variations. The total species richness was high during summer (3.5 + 0.47) followed by monsoon (2.9 + 0.6), postmonsoon (2.1 + 0.4) and minimum during winter (2.0 + 0.2).

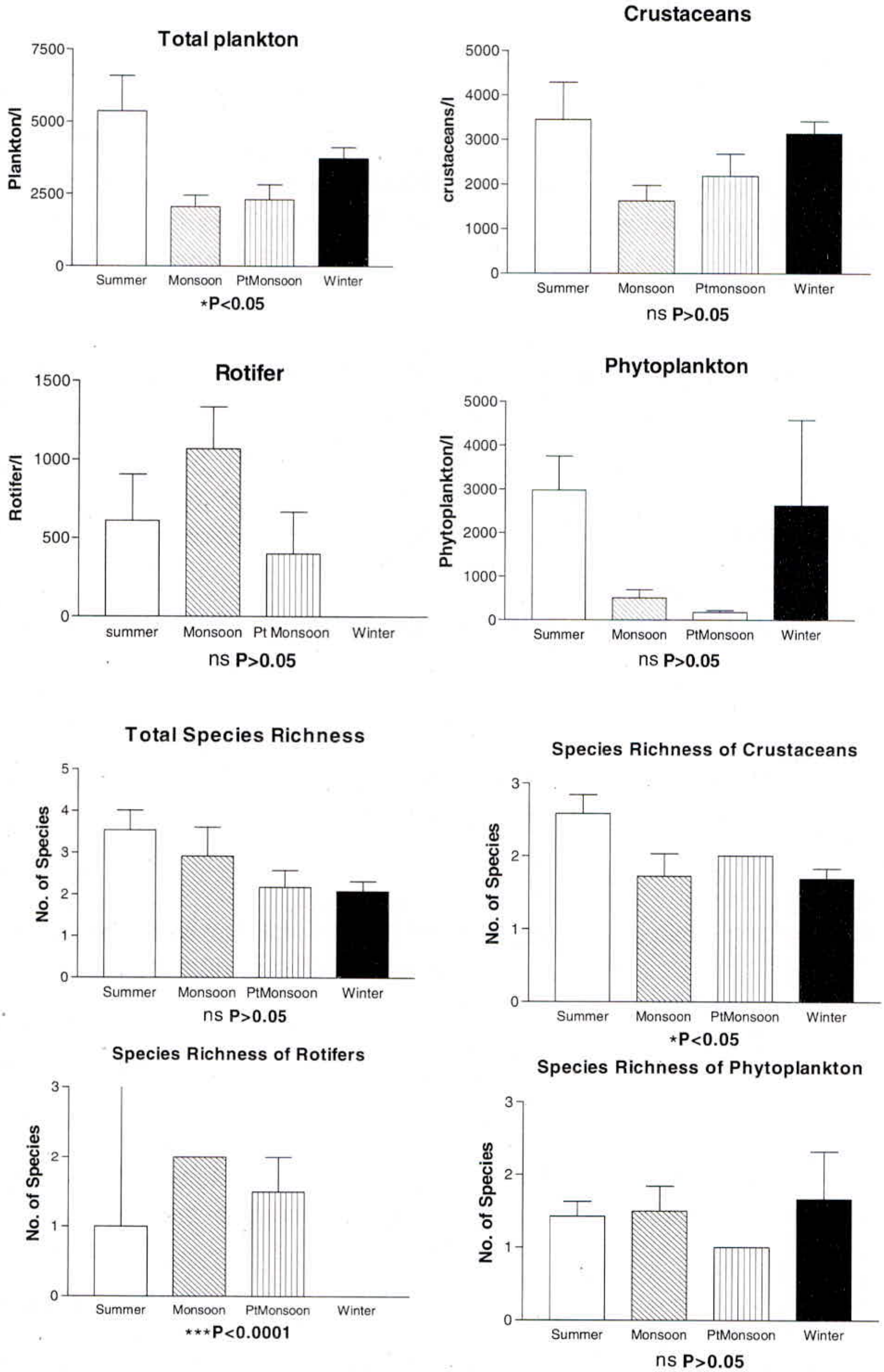

Fig. 2: The variation in the plankton density and species richness over the four seasons from March 2005 to March 2007 at HVP

DISCUSSION

At both the village ponds the trend in the seasonal variations in plankton density was almost same. Highest plankton density was noted during summer, when the water level was low and the plankton got concentrated while Minimum density of plankton was noted during monsoon when the water level was high and plankton were more distributed. In addition both the ponds were either flooded or overflowed during monsoon of both the years and hence, the plankton probably drifted along with the water that was lost with the flood. However, MVP is mainly under the influence of environmental fluctuations and hence the plankton density is showing highly significant variations in the distribution over the year. At HVP, the urban pond that has comparatively steady hydrologic conditions throughout the year the plankton densities showed significant variations ($P < 0.05$).

The total density of plankton was mainly due to Crustaceans during all the seasons. As expected the Crustacean densities at both the village ponds were high during summer when the water level was minimum, in the typical condition of waterbodies of the semi arid region of Gujarat. As water level recedes, the resultant emergent macrophytes are known to serve as hiding places for the planktonic microfauna, (Beklioglu and Moss, 1996). The plankton are known to come out of hiding during early hours of day when the samples were collected. This is the season when predation is expected to low on one side as hiding places are available. The increase in the nutrients because of the domestic waste that enters in the pond increases the productivity which in turn can increase Crustacean density. Minimum Crustacean density was observed at both the village ponds during monsoon as this was the time of dilution of the water in wetlands because of the input of water due to rainfall.

The other dominant group was Rotifer. Rotifers are the most cosmopolitan species of the aquatic ecosystem (Pejler, 1995). However, during winter they were in minority at MVP and absent at HVP. This is the season when the mercury goes down in the semi arid zone of Gujarat. Here mercury remains around 10° C, occasionally going further down. During such extreme environmental conditions the Rotifers are known to undergo diapause (Schroder, 2005). In summer increase in the density of Rotifers corresponds to decline in water level *i.e.* rotifers are concentrated more densely in summer. Moreover, during summer the littoral vegetation is exposed creating the best habitat for growth and production of Rotifers (Pejler, 1995). The higher rotifer densities at both the village ponds either during monsoon (HVP) or post monsoon (MVP) can be attributed to overflowing of the village ponds that probably created effect of a lotic ecosystem. This ecosystem is more favourable habitat for rotifers (Baranyi *et al.*, 2002). According to Townsend *et al*, (1997) Rotifers are more successful in the lotic ecosystem due to their short embryonic development and fast growth rate. At MVP, the Rotifer density dominated among other plankton groups during postmonsoon. This is the period when density of predators was low at MVP. It is known that the

Rotifer density is often influenced by the abundance of the food and the predation pressure (Urabe, 1992).

Phytoplankton are also known to undergo annual periodicity in lakes (Barbiero *et al.*, 1999). Changes in density and diversity of phytoplankton; and higher taxa, are commonly used for water quality assessment since long (Willén, E. 2001; Padisak *et al.*, 2006). The wetlands in semi arid zone of central Gujarat fall in subtropics which receive maximum photoperiod during summer invigorating growth of these aquatic autotrophs. Further, as the water level also decreases due to evaporation during summer, phytoplankton also get aggregated, resulting in further increase in their density. Various physical components are known to determine the composition of phytoplankton assemblages in lakes (Mischke, 2003, Madwick *et al.*, 2006) rather than the chemical factors (Pennak, 1946) In addition, the predation by the planktonic Crustaceans (the biotic component) have a major impact on the phytoplankton density as the former feeds on the latter one (Hann and Zrum, 1997). Hence when increase in phytoplankton density was noted increase in Crustacean density was also noted.

When the species richness was considered different trends were noted. At MVP the pond under the influence of natural subtropical climatic condition showed significantly significant variations whereas HVP, the pond under urban pressures with continuous organic input showed insignificant variations. This difference in species richness can be attributed to is mainly because of the difference in the hydrology of the two village ponds. The physical factors like hydroperiod and water spread are considered to be the major factors responsible for the formation of the ecological community (Shurin, 2000). At HVP the water level is fluctuating but the water spread/ cover does not differ prominently as a result the water regime does not show significant fluctuations whereas MVP dries up partially in summer decreasing the water spread and the pond becomes brackish during the same period as it is probably under the influence of the under ground water flow from the Mahi Estuary which is about 15-20 kms away from this pond (Deshkar, 2008). Though the difference in the species composition was observed the Crustaceans always dominated throughout the year at HVP while at MVP the Rotifers dominated the pond only once in postmonsoon.

When the plankton densities at the two ponds were compared, for the seasons differences insignificant differences were noted (Fig 3). However, as discussed earlier the trend and the seasonal variations showed differences due to the difference in the Hydrology of the two village ponds. In conclusion MVP is subjected to the diverse environmental changes and hence a highly significant differences were observed in the density of the Plankton all throughout the year. HVP is having the steady water input from the domestic sewage and hence even though the rains stops and the water level does not fluctuates, the water cover remains persistent throughout the year and hence lower statistical variations were observed in the density of the Plankton. Thus we can conclude that the location, anthropogenic pressure, hydrology and the water

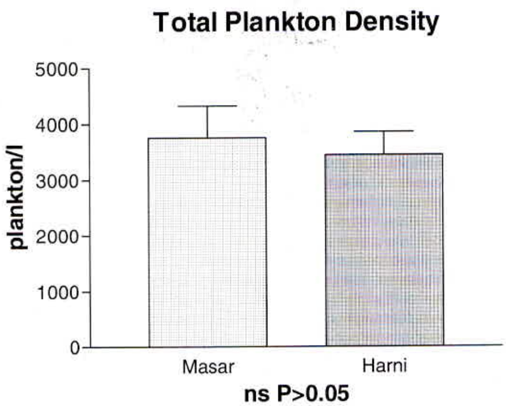

Fig. 3: The overall total plankton density at both the village pond from March 2005 to May 2007 (n = 48)

input play a major role in the seasonal variation in the density of the plankton. With species composition. Though there was no significant difference when the densities of plankton of two ponds were considered, the difference in the distribution pattern can be significantly noted. To maintain the ecology of wetland it is necessary to control the high load of unwanted nutrients from the domestic sewage which might bring about the eutrophic condition in the pond and finally lead to the death of the pond.

In conclusion it can be said that the phytoplankton densities in pond under the influence of natural environmental condition shows conspicuous variations whereas the plankton densities at pond under urban influence show variations of lower magnitude.

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