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Effects of Host Specificity in Parasitic Loranthaceae for Sodium and Potassium Distribution in Coastal Region of Cameroon

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Abstract: In this study, the effect of host specificity in parasitic in some mineral nutrient distribution was investigated in four Loranthaceae/host couples grown in the coastal region of Cameroon in order to determine physiological criteria of identification for the degree of specificity of Loranthaceae-host relationship. The distribution of potassium and sodium in plant parts of generalist Loranthaceae/host couples (*Phragmanthera capitata*/*Citrus maxima*, *P. capitata*/*Psidium guajava* and *P. capitata*/*Theobroma cacao*) was compared to a specialist Loranthaceae/couple (*Tapinanthus ogowensis*/*Dacryodes edulis*). After mineralization of plant organs of the parasite and the hosts, sodium (Na⁺) and potassium (K⁺) concentrations were determined by Flame photometer on 36 samples belonging to four Loranthaceae/host couples. Results showed a significant difference (p<0.05) in Na⁺ and K⁺ partitioning in *T. ogowensis* and *D. edulis* except in the non parasitized host leaf and parasitized sucker (p>0.05). The K⁺ distribution in generalist Loranthaceae (*P. capitata*) and its hosts (*C. maxima*, *P. guajava* and *T. cacao*) were higher in the plant parts than Na⁺ for *C. maxima* and *T. cacao*. It was not significantly (p>0.05) different on Na⁺ distribution in plant organs of *P. capitata* and its hosts. The results also revealed high accumulation (p<0.05) of Na⁺ in non parasitized host leaf and parasite leaf of *D. edulis* and low storage in *T. cacao* roots. The accumulation of K⁺ in the plant parts of *T. ogowensis* and its host (*D. edulis*) was lower (p<0.001) than those of *P. capitata* and his hosts (*C. maxima*, *P. guajava* and *T. cacao*). The distribution of K⁺ in plant parts could contribute to verify the degree of the host specificity in parasitic which could contribute to determine the potential for infestation of plant population by Loranthaceae in a natural ecosystem.

Key words: Host, generalist loranthaceae, specialist loranthaceae, specificity, ions partitioning

INTRODUCTION

The degree of specificity of parasite-host relationship depends on parasite groups (Rohde, 1993; Shaw, 1994). Parasites comprised the following: plant parasites (Loranthaceae), virus, some phytophagous insects, parasitoids, ecto and endoparasites of animals (Norton and Carpenter, 1998; Norton and De Lange, 1999). Each of them is marked with a life cycle associated with a single host individual due to affinity that is beneficial to the parasite relative to the host (Thompson, 1994). Few parasites are known to infect a single host species alone, with the usual behaviour among specialists (Hawksworth and Wiens, 1996). Five mistletoe species (*Amyema inophyllum*, *A. miquelii*, *A. miraculosum*, *A. preissii* and *A. quandang*) were strongly specific to the

host, occurring only on one or specie of closely related taxa (Yan, 2002). The generalists which use a large number of host species tend not to be restricted in their host range and show preference for some host species above others (Bernys and Chapman, 1994). The degree of host specificity in parasites can be favoured by their ability to adapt with many hosts (Norton and Carpenter, 1998). A generalist host is advantageous in diversified community because it permits the growth of parasites in many hosts that it comes across. If host populations are unknown and ephemeral, generalists are likely to occur (Thompson, 1994).

In the tropical region of Africa and especially in Cameroon, Loranthaceae are very common on woody that are for economic interest or not. They are group of shrubby parasites of aerial stems 77 genera and

950 species (Polhill and Wiens, 1998). Able to carry out photosynthesis and to elaborate requisite substances for their carbohydrate nutrition, they are characterised by the setting of the host's tissues, of a specific absorption system called sucker or haustorium (Boussim, 2002). Obligate autotrophic parasites (hemi parasites Lorantheaceae) dwell on branches of trees (Balle, 1982). They obtain water and solutes by diverting xylem sap from the host tree through direct xylem connections without production of functional roots (Boussim, 2002; Dibong *et al.*, 2008).

Differential accumulation of mineral element gives rise to high elements storage in mistletoe tissues involve in high transpiration rather than the host (Bannister *et al.*, 2002). Some mineral elements play a key role in plant (Taffouo *et al.*, 2010). Enzymatic processes that are necessary for plant growth are catalysed by potassium which intervenes in their water regulation (osmoregulation) (Taffouo *et al.*, 2004). This osmoregulation process acts on water transport in the xylem by maintaining high daily cell turgor pressure which inhibits cell elongation for growth. Potassium intervenes in proteins transport and control carbon dioxide uptake for photosynthesis during opening and closure of stomata which act in transpiration cooling (Amtmann *et al.*, 2006; Ashley *et al.*, 2006; Dadkhah, 2011). Sodium is one of the major nutrients, essential for plant growth and development in salt tolerant species (Desire, 2005; Taffouo *et al.*, 2009, 2010). Osmotic pressure increases with high sodium concentration in the stem which allows water to flow into the stem in order to maintain equilibrium of concentration. Bannister *et al.* (2002) found that the concentrations of Ca and Mg in mistletoes leaves were similar to those of their hosts whereas the concentrations of K, Na and P in mistletoes were higher in their leaves than their hosts. Seven genera and about twenty seven species are pointed out in Cameroon (Balle, 1982). Among plant parasites (Lorantheaceae), *Phragmanthera capitata* highly attacks most of the cultivated or spontaneous trees (citrus fruits, avocado trees, cocoa trees, coffee trees and guava trees) while *Dacryodes edulis*, is highly host specific, occurring on only one host species (*Tapinanthus ogowensis*) (Dibong *et al.*, 2009). The retranslocation of mineral nutrients in plant organs of the Lorantheaceae generalist and Lorantheaceae specialist has apparently never been investigated but is not likely to be substantial as xylem flow is more or less one way and significant active retranslocation of inorganic ions from hemi-parasite to host is improbable in the absence of phloem links (Glatzel, 1983).

This study was undertaken to evaluate the effect of host specificity in parasitic in some mineral nutrient distribution in four Lorantheaceae/host couples grown in the coastal region of Cameroon in order to determine physiological criteria of identification for the degree of specificity of Lorantheaceae-host relationship.

MATERIALS AND METHODS

Site description: The experiment was conducted in the coastal region of Cameroon (latitude, 03°40'-04°11'N; longitude, 09°16'-09°52'E; altitude, 13 m). The climate belongs to the equatorial domain of a particular type called "Cameroonian" characterises by two seasons with a lengthy rainy season (at least 9 months), abundant rainfalls (about 4000 mm per year), high and stable temperatures (26.7°C). The relative humidity remains high the whole year and near to 100% (Din *et al.*, 2008).

Samples collection and analysis: Samples were made up of four Lorantheaceae/host couples in Douala region. For the *Phragmanthera capitata* parasitism, generalist Lorantheaceae (Dibong *et al.*, 2010), couples considered were: *P. capitata/Citrus maxima*, *P. capitata/Psidium guajava* and *P. capitata/Theobroma cacao* while for *Tapinanthus ogowensis* parasitism, specialist Lorantheaceae (Dibong *et al.*, 2008), couple studied was: *T. ogowensis/Dacryodes edulis*. For each couple, the roots of the host (HR), the suckers of the parasite (PS), the Parasite's Leaves (PL), the leaves of the non Parasitized Host's Leaves (NPHL) and Parasitized Host's Leaves (PHL) have been sampled. The stocking and transport to the laboratory were done in plastic bags. In the laboratory, the samples were washed with distilled water and oven-dried for 72 h at 60°C. For the analysis of Na⁺ and K⁺, five samples each of 0.5 g of the roots of the host, the suckers of the parasite, the parasite's leaves, the leaves of the non parasitized hosts and parasitized host's leaves were thoroughly grinded and homogenized into 20 mL of HCL 1/10 for 24 h. Sodium and potassium were determined by the method Taffouo *et al.* (2008) using Jenway Flame photometer.

Statistical analysis: Data are presented in term of mean (\pm standard deviation). Multiple comparisons of several means was set up using analysis of variance (ANOVA) and the post-hoc pair wise analysis was set up using the Student-Newman-Keuls procedure (Taffouo *et al.*, 2008) when the normality and equal variance conditions passed. Multiple comparisons of data noted in experimental groups *versus* those recorded in the single control group were set up using the Dunnett's procedure (Sigma stat software).

RESULTS

Ions partitioning

Sodium and potassium concentrations in plant organs of *Tapinanthus ogowensis* (specialist Loranthaceae) and his host (*Dacryodes edulis*): The results showed a significant difference ($p < 0.05$) in sodium and potassium partitioning contents in the host roots, the leaves of the non parasitized host's leaves and the parasite's leaves of *T. ogowensis* and his host (*D. edulis*) except in the non parasitized host leaf and parasitized sucker. The non parasitized host Leaf (47.72 g kg^{-1}), the host roots (17.48 g kg^{-1}) and the parasite leaf (33.52 g kg^{-1}) had the higher concentrations of potassium than those of sodium ($37.90, 8.76$ and 22.86 g kg^{-1} , respectively) (Fig. 1).

Sodium and potassium concentrations in plant organs of *Phragmanthera capitata* (generalist Loranthaceae) and his hosts (*Citrus maxima*, *Psidium guajava* and *Theobroma cacao*): The distribution of potassium in *P. capitata* and his hosts (*C. maxima*, *P. guajava* and *T. cacao*) were significantly higher in the host roots ($110.60, 16.32$ and 68.7 g kg^{-1} , respectively), the leaves of the non parasitized host's leaves ($135.04, 47.80$ and 143.08 g kg^{-1} , respectively), the parasitized host's leaves ($115.76, 34.64$ and 106.62 g kg^{-1} , respectively), the suckers of parasite ($87.29, 36.18$ and 97.44 g kg^{-1} , respectively) than sodium in plant organs of *C. maxima* ($11.4, 23.33, 14.06, 9.30$ and 14.2 g kg^{-1} , respectively),

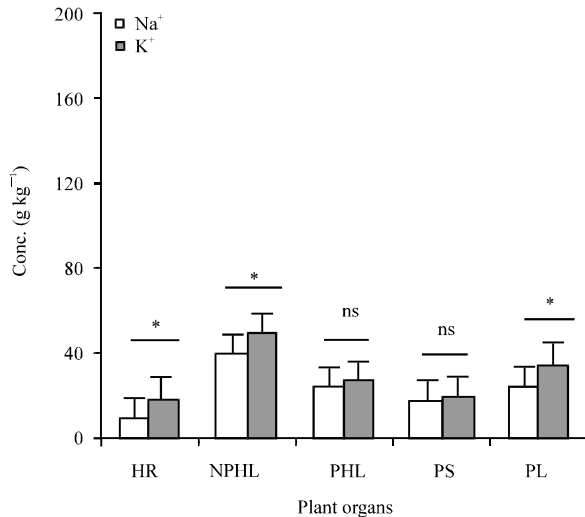


Fig. 1: Na⁺ and K⁺ partitioning in *Tapinanthus ogowensis* (specialist Loranthaceae) and his host (*Dacryodes edulis*) in Douala region, HR: Host roots, NPHL: Non parasitized host leaf, PHL: Parasitized host leaf, S: Parasite sucker, SPa: Parasitized sucker, PL: Parasite leaf, The bars indicate Mean±SE, * $p < 0.05$, ns: Not significant

and the parasite's leaves ($117.52, 45.12$ and 122.32 g kg^{-1} , *P. guajava* ($9.66, 26.90, 17.06, 12.98$ and 19.84 , respectively) and *T. cacao* ($5.76, 29.90, 14.58, 9.1$ and 14.86 g kg^{-1} , respectively) (Fig. 2a-c).

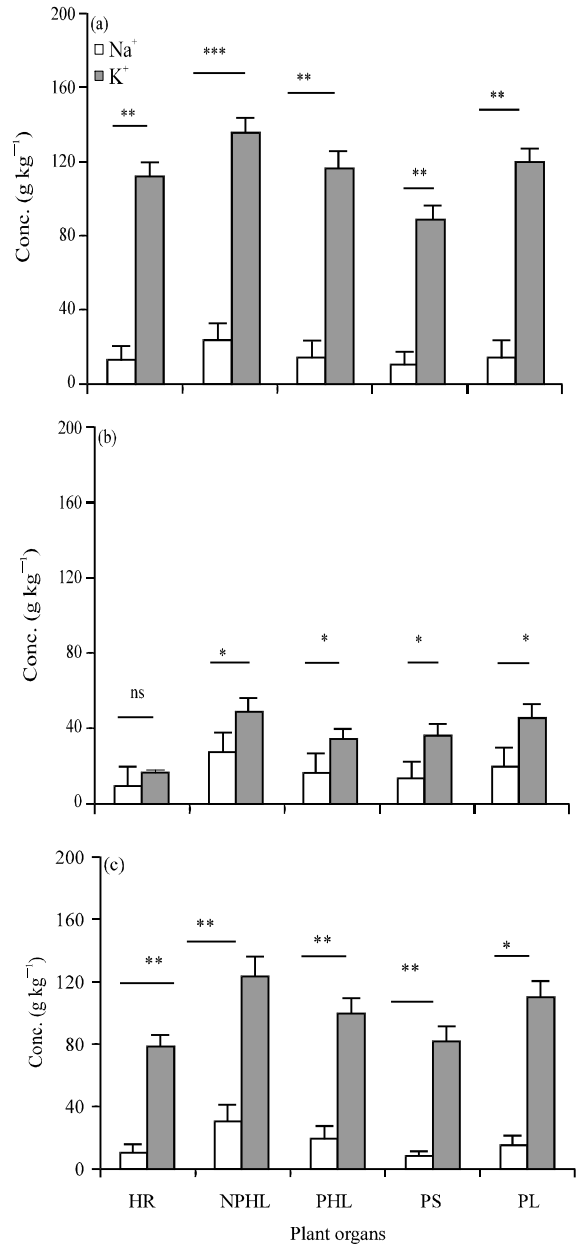


Fig. 2(a-c): Na⁺ and K⁺ partitioning in *Phragmanthera capitata* (generalist Loranthaceae) and his hosts in Douala region, (a) *Citrus maxima*, (b) *Psidium guajava* and (c) *Theobroma cacao*, HR: Host roots, NPHL: Non parasitized host leaf, PHL: Parasitized host leaf, S: Parasite sucker, PL: Parasite leaf, The bars indicate Mean±SE, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, ns: Not significant

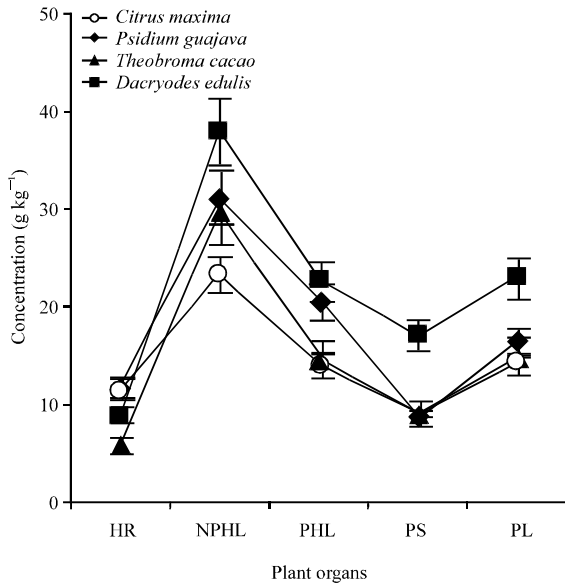


Fig. 3: Na⁺ partitioning in three host species of *Phragmanthera capitata* (generalist) and one host species of *Tapinanthus ogowensis* (specialist) in Ndogbong chieftaincy's orchard, HR: Host roots, NPHL: Non parasitized host leaf, PHL: Parasitized host leaf, PS: Parasite sucker, PL: Parasite leaf

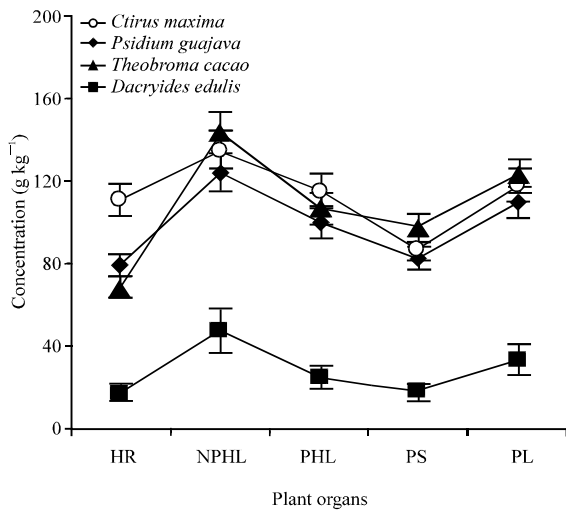


Fig. 4: K⁺ partitioning in three host species of *Phragmanthera capitata* (generalist) and one host species of *Tapinanthus ogowensis* (specialist) in Ndogbong chieftaincy's orchard, HR: Host roots, NPHL: Non parasitized host leaf, PHL: Parasitized host leaf, PS: Parasite sucker, PL: Parasite leaf

The average sodium distribution in plant organs was similar for *P. capitata* and his hosts.

Sodium concentration in host species of *Phragmanthera capitata* and *Tapinanthus ogowensis*: The sodium distribution in three host species (*C. maxima*, *P. guajava* and *T. cacao*) of *P. capitata* and one host species (*D. edulis*) of *T. ogowensis* significantly varied for both hosts. The results showed high accumulation of sodium in non parasitized host leaf (38.20 g kg⁻¹) and parasite leaf (22.41 g kg⁻¹) of *D. edulis* and low storage in *T. cacao* roots (5.12 g kg⁻¹) (Fig. 3). The amount of sodium in the host roots, the leaves of the non parasitized host's leaves, the parasitized host's leaves, the suckers of parasite and the parasite's leaves was low in *P. capitata* and her hosts compared to *T. ogowensis* and his host species (Fig. 3). Otherwise, the highest concentrations of sodium were observed in plant parts of *D. edulis*.

Potassium concentration in host species of *Phragmanthera capitata* and *Tapinanthus ogowensis*: The potassium accumulation in the host roots (17.46 g kg⁻¹), the leaves of the non parasitized host's leaves (135.04 g kg⁻¹), the parasitized host's leaves (25.10 g kg⁻¹), the suckers of parasite (18.18 g kg⁻¹) and the parasite's leaves (33.52 g kg⁻¹) of *T. ogowensis* and his host (*D. edulis*) was significantly lower (p<0.001) than those of *P. capitata* and *C. maxima* (110.60, 135.04, 115.76, 87.26 and 117.52 g kg⁻¹, respectively), *P. guajava* (9.66, 26.90, 17.06, 12.98 and 19.84, respectively) and *T. cacao* (5.76, 29.90, 14.58, 9.1 and 14.86 g kg⁻¹, respectively) plant organs (Fig. 4). Otherwise, the lowest concentrations of potassium were observed in plant parts of *D. edulis*.

DISCUSSION

The non parasitized host Leaf, the host roots and the parasite leaf had the higher concentrations of potassium than that of sodium (Fig. 1). This result implies competition between sodium and potassium absorption in the *Tapinanthus ogowensis* (specialist Loranthaceae) and his host (*Dacryodes edulis*), resulting in a Na/K antagonism. This is an agreement with the results obtained by Turan *et al.* (2007), Dibong *et al.* (2010), Taffouo *et al.* (2009, 2010) and Sadeghi and Shourijeh (2012). Potassium accumulated more than Na⁺ in plant organs suggesting that K⁺ is the principal element responsible for osmotic adjustment in these species. The lack of a phloem connection between host and parasite, combined with circulation of elements in the host phloem and their transfer into the host xylem, provides a mechanism that explains the accumulation of phloem-mobile elements in the Loranthaceae (Bannister *et al.*, 2002).

The amount of sodium in plant organs was low in all Lorantheaceae species studies and their hosts (Fig. 3). The low concentration of sodium compared to potassium in our work could be explained by the fact that sodium has a very specific function in the concentration of carbon dioxide in a limited number of C4 plants and thus essential to these plants, but this in itself is insufficient to generalize that sodium is essential for Lorantheaceae. This is consistent with the results obtained by others researchers (Khan *et al.*, 1997; Taffouo *et al.*, 2006; Agong *et al.*, 2003).

An interesting finding of the present study is the lowest accumulation of potassium in the plant parts of *T. ogowensis* (specialist Lorantheaceae) and his host (*D. edulis*) compared with *P. capitata* (generalist Lorantheaceae) and his hosts (*C. maxima*, *P. guajava* and *T. cacao*) (Fig. 4). The high storage of potassium in plant parts of *P. capitata* and his hosts could be due by a key role which some essential mineral elements such as potassium play in plant (Taffouo *et al.*, 2010). According to Dadkhah (2011) and Sadeghi and Shourijeh (2012), potassium plays a vital role in photosynthesis, translocation of photosynthates, protein synthesis, osmoregulation and control of ionic balance and activation of plant enzymes. There have been very few tracer studies of the routes taken by nutrients in reaching and entering Lorantheaceae. In many Lorantheaceae, the host branch above the point of attachment atrophies and eventually dies. This is well documented by Dibong *et al.* (2010) who considered that the host branch was starved of water and mineral nutrients, which had been diverted to the parasite. Although nutrients may well reach the haustorium *via* host xylem, it is clear, on anatomical grounds, that few will enter the parasite *via* a xylem continuum. In every case the potassium content of Lorantheaceae tissue was disproportionately higher than the contents of sodium in generalist and specialist. Potassium enrichment has traditionally been considered a greater of hemi-parasites and was interpreted as a consequence of the absence of a phloem connection between host and hemi-parasite (Ansiaux, 1958; Lamont, 1983). In the host potassium is cycled between leaves and sites of photosynthetic utilization in the wake of transport in the phloem. In the hemi-parasite it cannot cycle beyond the host-parasite interface and potassium imported with xylem sap is thus trapped in the hemi-parasite phytomass (Glatzel, 1983). An explanation suggested is based on the fact that substantial amounts of potassium cycle in plants. During phloem loading of sucrose, potassium is also taken up into the phloem, moves with the sugar to the sites of photosynthetic utilization and is then free to enter the xylem sap again and ascend into the leaves. Potassium enrichment in hemi-parasite would then be a consequence of the site host because of the lack of phloem links and thus a passive process. Lamont and Southall (1982)

thought that active uptake by parenchyma cells at the host-Lorantheaceae interface might be responsible for potassium enrichment in autotrophic.

CONCLUSION

The present findings show that Lorantheaceae obtained their potassium and sodium requirements from their hosts. Relative uptake is dependent on the type of nutrient elements, species of Lorantheaceae, plant organs and identity of the host. The results also showed a differential accumulation of sodium and potassium, leading to greater accumulation of those elements in Lorantheaceae tissues (suckers of parasite and parasite's leaves). The host branch reaching beyond the point of attachment of the Lorantheaceae may provide mineral nutrients to the Lorantheaceae. The accumulation of K⁺ in the plant parts of *T. ogowensis* and his host (*D. edulis*) was lower (p<0.001) than those of *P. capitata* and his hosts (*C. maxima*, *P. guajava* and *T. cacao*). The distribution of K⁺ in plant parts could contribute to verify the degree of the host specificity in parasitic Lorantheaceae.

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