Table 2 Lethal concentration (LC_{50} & LC_{90}) of hexane extracts of *U. massaica* plant parts against different aquatic stages of *An. gambiae* mosquitoes

Life stage	Plant part	LC_{50}			LC_{90}			Chi-Square Tests		
		Estimate	95% confidence limit for log $_{10}$ (Concentration)		Estimate	95% confidence limit for log $_{10}$ (Concentration)		χ^2	df	*p*
			Lower	Upper		Lower	Upper			
Egg	Leaves	103.30[a]	1.73	2.62	39.11[a]	2.88	5.266	179.96	22	0.000
	Stem	7.81[a]	0.80	0.98	41.87[a]	1.49	1.799	133.24	22	0.000
	Roots	6.89[a]	0.69	0.96	61.19[a]	1.60	2.079	167.86	22	0.000
L3	Leaves	8.53[a]	0.85	1.02	17.99[a]	1.15	1.430	314.57	22	0.000
	Stem	3.88[a]	0.54	0.64	7.88[a]	0.83	0.994	113.84	22	0.000
	Roots	1.05[b]	-0.30	0.16	2.67[b]	0.35	0.486	33.79	22	0.052
Pupae	Leaves	70.05[a]	1.77	1.96	13.91[a]	1.99	2.383	295.15	22	0.000
	Stem	4.94[a]	0.63	0.76	9.69[a]	0.91	1.108	193.38	22	0.000
	Roots	31.34[a]	1.25	1.92	56.28[a]	2.90	6.056	138.86	22	0.000

Notes: As described (Table 1) except for “b” to denote significant influence of dose on the aquatic stages

In this study methanol extracts were more potent than hexane extracts. Methanol is more polar than hexane and according to the findings of Thouri et al. (2017), Borges et al. (2020) and Nguyen et al., (2021) possess optimal extraction ability as well as capacity to conserve the stability of the chemical structure of desired compounds. This finding was similar to others that demonstrated the influence of solvent type on extracted bioactives as well as larviciding potency (Anupam et al., 2012). However, it is noted that there is not a single standard solvent for optimal bioactive extraction as different solvents react differently for different plant matrices (Ngo et al., 2017).

Mosquitoes are a very important group of arthropods based on their role in the transmission and impact of mosquito borne infection (MBI) to humanity (WHO, 2020) and thus have been under constant human surveillance. Such has today yielded the best possible approaches of mosquito attack some of which include oviciding (Khatoro et al., 2021), larviciding (Yohana et al., 2022), pupiciding (Khatoro et al., 2021) and adulticiding (Muhammed et al., 2022) targeting the life stages of the vector. But again, the success observable today in managing malaria vector population is only possible because the ontogeny of the vector is predictable. As the adage goes, ‘a chain is as strong as its weakest link’. The vector’s aquatic stages (eggs, larvae and pupae) are the weakest link in the chain (life cycle). This is because their movement is restricted to the breeding ground (stagnant water) and are unable to escape to avoid “invasion or attack” by natural enemies (predators) or anthropogenic neutralization (through insecticides). It follows therefore that programmes that target mosquito immature stage are highly impactful (Chung et al., 2009; Conti et al., 2010). Indeed, larviciding has been the most preferred malaria vector control tool (Thomas, 2018) as the statistics on reduced malaria incidence and mortality due to reduced larval and adult mosquito abundance (Afrane et al., 2016; Ingabire et al., 2017) has largely been due to targeting the larvae (William et al., 2018; Zhou et al., 2020). When the larvicide is a biopesticides as is in this study, the programme transforms into the use of green biopesticide and biodiversity conservancy. This is because the biopesticide is not only lethal but since extract is a composition of varied acting bioactives, the vectors don’t get to mount effective resistance against them. Additionally, since plants from which the biopesticides are derived are easily accessible and regenerative, the programme is not only sustainable and safe (Govindarajan et al., 2016), it also leads to conservation of the plant resources. It is therefore a solution to insecticide resistance mosquitoes, sustainable use and conservation of resources (Rahimi et al., 2019; Rahimi et al., 2020).

3.1 Conclusion

It is concluded that leaf, stem and root methanol and hexane crude extracts of *U. massaica* are required in small amount to kill immature *An. gambiae* mosquitoes. Their toxicity levels are promising as candidates for natural mosquito control strategies.