

Chapter 1: Introduction and Objectives

Alternanthera Forssk. is the second largest genus in the subfamily Gomphrenoideae of Amaranthaceae with 80–200 species distributed in the tropics and subtropics, especially tropical America (Mabberley, 2008; Townsend, 1993). Most of the members are perennial or annual herbs that show erect, ascending, creeping, decumbent or floating growth habit (Backer, 1949; Trimen, 1980; Womersley, 1978).

In this genus, the morphology of 13 species is described (Table 1). Only the embryology of *A. sessilis* (L.) R.Br. ex DC. is reported (Table 2) and the pollen morphology of 20 species are studied (Table 3).

Studies of *Alternanthera* in Malaysia date back to the 18th century when Ridley (1924) reported 16 species widely distributed (cosmopolitan), but only the green leaf form of *A. sessilis* was described in the Malay Peninsula. Subsequently, *A. sessilis*, *A. sessilis* var. *tenuissima* (Suess.) Backer, *A. repens* J.F.Gmel., *A. ficoides* (L.) R.Br. var. *bettzickiana* (NICH.), *A. philoxeroides* (Mart.) Griseb., *A. brasiliana* (L.) Kuntze and *A. porrigens* (Jacq.) Kuntze from Malesia were also described (Backer, 1949). Only *A. sessilis* var. *tenuissima* has been reported as endemic to New Guinea. The other five species are introduced from tropical America (Backer, 1949). *Alternanthera triandra* Lam. has been recorded as a common weed in Malaya (Henderson, 1959) and *A. paronychioides* A.st.-Hil. has been introduced as an alien into Indo-Malesia (Veldkamp, 1971). In Turner's catalogue of Malayan plants (1995), only three species (*A. philoxeroides*, *A. bettzickiana* and *A. sessilis*) were reported.

Alternanthera has various useful species. In ethnobotany, *A. sessilis* has been used to treat various diseases by residents from the Malay Peninsula (Burkill & Haniff, 1930; Lemmens & Horsten, 1999); China (Perry, 1980); India (Lemmens & Horsten,

1999) and Southeast Asia (Christophe, 2000). The traditional uses of *A. sessilis* have been given some validation by modern pharmacological studies. The species shows promising antimicrobial activities (Jalalpure *et al.*, 2008; Johnson *et al.*, 2010; Kumaresan *et al.*, 2001; Ragasa *et al.*, 2002; Valarmathy *et al.*, 2010); antioxidant activities (Balasuriya & Dharmaratne, 2007; Bhaskar *et al.*, 2007; Shyamala *et al.*, 2005) and diuretic activities (Roy & Saraf, 2008). Apart from being a useful medicinal herb, *A. sessilis* is also a popular leafy vegetable (Burkill, 1985; Trimen, 1980; Wan Hassan, 2006).

Alternanthera brasiliana is another well-known herb used in folk medicine especially in Brazil (Agra *et al.*, 2007). The pharmacological activities of *A. brasiliana* include antiviral (Lagrota *et al.*, 1994); antifungal (Johann *et al.*, 2010); antinociceptive (Barua *et al.*, 2009) and analgesic (De Souza *et al.*, 1998; Macedo *et al.*, 1999). *Alternanthera brasiliana* is widely cultivated as an ornamental plant in Peninsular Malaysia (personal observation). Interestingly, *A. brasiliana* is able to set fruit in the absence of male gametes (mature pollen grains were not observed in the field).

Alternanthera bettzickiana (Regel) G.Nicholson is cultivated as an ornamental plant and as ground cover to protect soil from rain-wash (Backer, 1949). It has been a sterile plant ever since it was introduced to Malesia (Backer, 1949). In the field, fruits do not develop after flower anthesis and they eventually degenerate (personal observation).

Although *A. sessilis* is scientifically proved to have several pharmacological activities, these two species are also a common weed (Lemmens & Horsten, 1999). *Alternanthera sessilis* is reported as an invasive weed in European and Mediterranean Plant Protection Organization (EPPO) countries (Austria, Czech Republic, Estonia,

France, Germany, Hungary, the Netherlands, Latvia, Switzerland and Turkey) (Brunel, 2009), South Africa and Australia (Mabberley, 2008).

As research on the potential useful aspects of *Alternanthera* species progresses, there are very little studies on its reproductive biology as well as cultivation programmes for these species. Micropropagation of *A. sessilis* has been developed to fulfil the high demand of this plant in India (Boro *et al.*, 1998; Gnanaraj *et al.*, 2011; Singh *et al.*, 2011). Recently, another colour of *A. sessilis*, the red leaf form, has been commonly cultivated as a medicinal herb by local (personal observation). *Alternanthera sessilis* 'Red' and 'Green' looks similar except for the colour. Hence, this project is undertaken based on several objectives.

Firstly, this project aims to elucidate the reproductive biology of *A. sessilis*, *A. brasiliiana* and *A. bettzickiana* because they have the potential of commercial value. The second objective is to investigate the embryology of *Alternanthera* because the previous information is insufficient. In addition, factors contributing to pollen grain abortion in *A. brasiliiana* and undeveloped fruit in *A. bettzickiana* could be determined from the embryological studies.

The third objective is to investigate the pollen morphology of *Alternanthera* because the previous information is not only insufficient but also not associated with voucher specimens. The last objective is to find differences to distinguish *Alternanthera sessilis* 'Red' and 'Green' to avoid mislabelling in herbal industry.