

Assessment of Morphological Diversity of *Cuscuta* Species based on Floral Morphology

Emmy Chepkoech^{1,*}, Lucas Ngode², Lynnete Oimbo³, Bonface Alkamoi²,
and Costa Kokwon⁴

ABSTRACT

The genus *Cuscuta* L. are obligate stem parasites, with long, multi-branched, modified thread like stem, attacking an extensive range of host plants. The *Cuscuta* species has cosmopolitan occurrence and are widely distributed throughout the temperate and tropical zones and colonizes diversity of habitats. Though, *Cuscuta* spp. is known to affect a number of crop and non-crop species globally, there is limited information on biology, ecosystem and farmers' knowledge, existence species of diversity and threat to crop production. Furthermore, knowledge on the existence of variation within a species is a prerequisite for developing sustainable management strategies for *Cuscuta* spp. in a specified agrosystems as well as making decision for comprehensive management practices for the weed. Therefore, the aim of the study was to assess the morphological diversity of *Cuscuta* Species based on floral morphology in Uasin Gishu County, Kenya. The study was carried out in Uasin Gishu County across the six sub-counties using purposive and convenient sampling design. The study involved Morphological identification by examining *Cuscuta* species general appearance and the microscopic flower morphology examination. The morphology of the floral characters revealed distinct *Cuscuta* species from the accessions collected from Uasin Gishu County, Kenya. Concisely, the flowers were microscopically identified to the species level across all the samples and showed that the clusters contained of five petals, five sepals and five stamens. *Cuscuta* species showed tremendous diversity in Uasin Gishu County with *Cuscuta reflexa* exhibited wide distribution in the County. Characterization of species provide valuable information for extensive analysis and precise identification of *Cuscuta* and develop better management and utilization strategies.

Keywords: *Cuscuta*, diversity, floral, microscopic.

1. INTRODUCTION

The genus *Cuscuta* (dodder) belong to the Convolvulaceae family, comprise of about 170–200 species of parasitic plants that are spread globally and occupy an extensive range of habitats, and concomitantly adapted to the diverse environmental conditions and niches (Yunker, 1932; Costea, 2007; Costea & Stefanović, 2009). *Cuscuta* is nearly cosmopolitan in distribution; occupying almost every continent, causing far-reaching damage to both crop and non-crop species worldwide (Dawson *et al.*, 1994; Kaiser *et al.*, 2015). Approximately 15–20 *Cuscuta* species worldwide are known as pests that infest several crops globally and most of the countries regulations targets the whole genus on various quarantine lists (Lanini & Kogan,

2005; Costea & Tardif, 2006; Costea & Stefanović, 2009). *Cuscuta* species causes harm due to parasitism; the most severe form of negative interaction in which one of the associates becomes a heterotroph living at the expense of the other, its host.

The lack of leaves, clustered or short racemes of flowers, corollas with five fimbriate scales, presence of haustoria, and acotyledonous embryo make the genus *Cuscuta* clearly unique from other Convolvulaceae genera (Stefanović *et al.*, 2007). Due to the highly diminished or almost missing vegetative organs (roots, leaves, and stems), as well as the tiny floral organs, *Cuscuta* species are particularly difficult to classify. Due to their co-growth with the corolla tube, the stamens are equal in number to the corolla lobes. The ovary is bilocular and contains 2–4

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¹ School of Agriculture and Biotechnology, Department of Biotechnology, University of Eldoret, Kenya.

² School of Agriculture and Biotechnology, Department of Seed, University of Eldoret, Kenya.

³ School of Environmental Studies, Department of Environmental science, University of Eldoret, Kenya.

⁴ School of Agriculture and Biotechnology, Department of Agricultural Economics and Rural Development, University of Eldoret, Kenya.

* Corresponding Author:

e-mail: emychepkoech@gmail.com



ovules. The two styles may stand alone or be fused together, and the stigmas may be capitate, spherical, or extended. The fruit is a conical, globular, or flattened capsule with 2–4 tiny seeds that is irregularly dehiscent or indehiscent. (Wright et al., 2012; Riviere & Riviere, 2013; Olszewski et al., 2020). Numerous studies on seed (Khalik Abdel, 2006; Olszewski et al., 2020), pollen (Welsh Mark & C., 2010; Wright et al., 2012), stigma (Mishra, 2009) and infrastaminal scales (Riviere & Riviere, 2013) and fruit of *Cuscuta* species and the overall diversity have reported on the evolution, morphology features, and microscopic assessment.

The knowledge of genetic diversity's scope, and description is an important informative tool for the detection of duplicates, effective extension services and better characterization for further management strategies to be put in place. Morphological characterization is the first step in description and classification of genetic resources of any plant species. The study was however, carried out to comprehend the thorough *Cuscuta* species-based examination of morphological characteristics in Uasin Gishu County.

2. MATERIALS AND METHODS

2.1. Study Area

The study survey was carried out in Uasin Gishu county located in Western part of Kenya across the six sub-counties namely; Turbo, Kesses, Moiben, Soy, Kapseret and Ainabkoi to understand the diversity of *Cuscuta* species. Agriculture is the chief economic activity in the County which is dominated by mixed farming systems supporting over 80% of the rural population's household income and food security. The County has a total population of 1,163,186 and measures approximately, 3,392.2 km² (Kenya National Bureau of Statistics (KNBS), 2010). Uasin-Gishu County borders Elgeyo Marakwet County to the East, Trans-Nzoia County to the North, Kericho County to the South, Nandi County to the South West and Kakamega County to the North West (Government of Kenya (GoK), 2012). The County has an average altitude of above 2000 m above sea level (masl), bi-modal rainfall (long rains starting from mid-March to late May and short rains starts from mid-October to late December) and temperature range of 8.4°C–27°C. The average rainfall in the County is between 500–2600 mm per annum. The soil type is rhodic ferralsol (UNESCO, 1977).

2.2. Sampling Design

The study design was purposive and convenient sampling across the six sub-counties in Uasin Gishu County. The study involved Morphological identification by examining *Cuscuta* species general appearance and the microscopic flower morphology examination.

2.3. Microscopic Identification

The flower samples were also collected from natural populations in August 2020 to March 2021 for microscopic analysis. Reproductive morphological observations, flowers and seeds were examined using a stereomicroscope (Olympus SZX16; Tokyo, Japan). Ten flowers per

sample were analyzed. Morphological identification was executed according to Olszewski et al. (2020) and Yunker (1932) modified descriptor. Briefly, flowers were either used immediately after collection or rehydrated before microscopy. The observation and examination of different parts of a full flower (sepals, petals, gynoecium and androecium) were also done and photographed. Thereafter, carefully dissected and photographed with focus given to specific areas such as the gynoecia, number of parts, fusion (or lack of) of the styles as well as the size and shape of stigmas. Ovaries were also dissected, then the number, size and color of ovules observed and photographed.

2.4. Data Collection and Analysis

Data was collected on morphological traits stem color (yellow, orange or purple), stem twinning (clockwise or anticlockwise) and flower color (white to pink or yellow to cream). The data was analyzed and reported as percentage and number of *Cuscuta* species.

3. RESULTS AND DISCUSSION

The morphological characters and microscopic anatomical observations of *Cuscuta* species showed tremendous diversity in Uasin Gishu County (Fig. 1). *Cuscuta* species is found distributed across the world with enormous species diversity in tropical and sub-tropical regions and reported to colonize an extensive variety of hosts across several environments (Lanini & Kogan, 2005; Hwang et al., 2013; Kumari et al., 2017). The *Cuscuta* species showed the anticlockwise stem twinning of the host plant attachment. The twining induction response to the host plant has been reported to be influenced through far-red and blue lights which together with tactile pressure induce haustorial formation (Tada et al., 1996a; Furuhashi et al., 2011) growth toward light sources parasitizing potential host plants.

The morphology of the floral characters revealed 3 distinct *Cuscuta* species from the accessions collected from Uasin Gishu County, Kenya (Table I; Fig. 1). Succinctly, flowers were microscopically identified to the species level across all the samples and showed that the clusters contained of five petals, five sepals and five stamens. The presences of five petals that are connected with each other by bridges of the developing filaments of the stamens and a long corolla- filament tube have been reported (Prenner et al., 2002; Sharma & Kapoor, 2014).

The study reported that the stem color of *Cuscuta* species varied from greenish-yellow being reported in 90%, orange (8%) and purple (2%) while majority the flower color was yellow to cream (90%). Generally, the observation indicated that young *Cuscuta* stem appeared green in color while older mature stems appeared yellow. The green stem color in the young *Cuscuta* species or the seedling stage shows the existence of chlorophyll, though it lacks roots and cannot absorb water by themselves, despite the genus being classified as holoparasitic. The *Cuscuta* green color can turn into orange or purple after parasitization, highlighting that plant gains energy from a host and does not need to photosynthesize (Furuhashi et al., 2011).

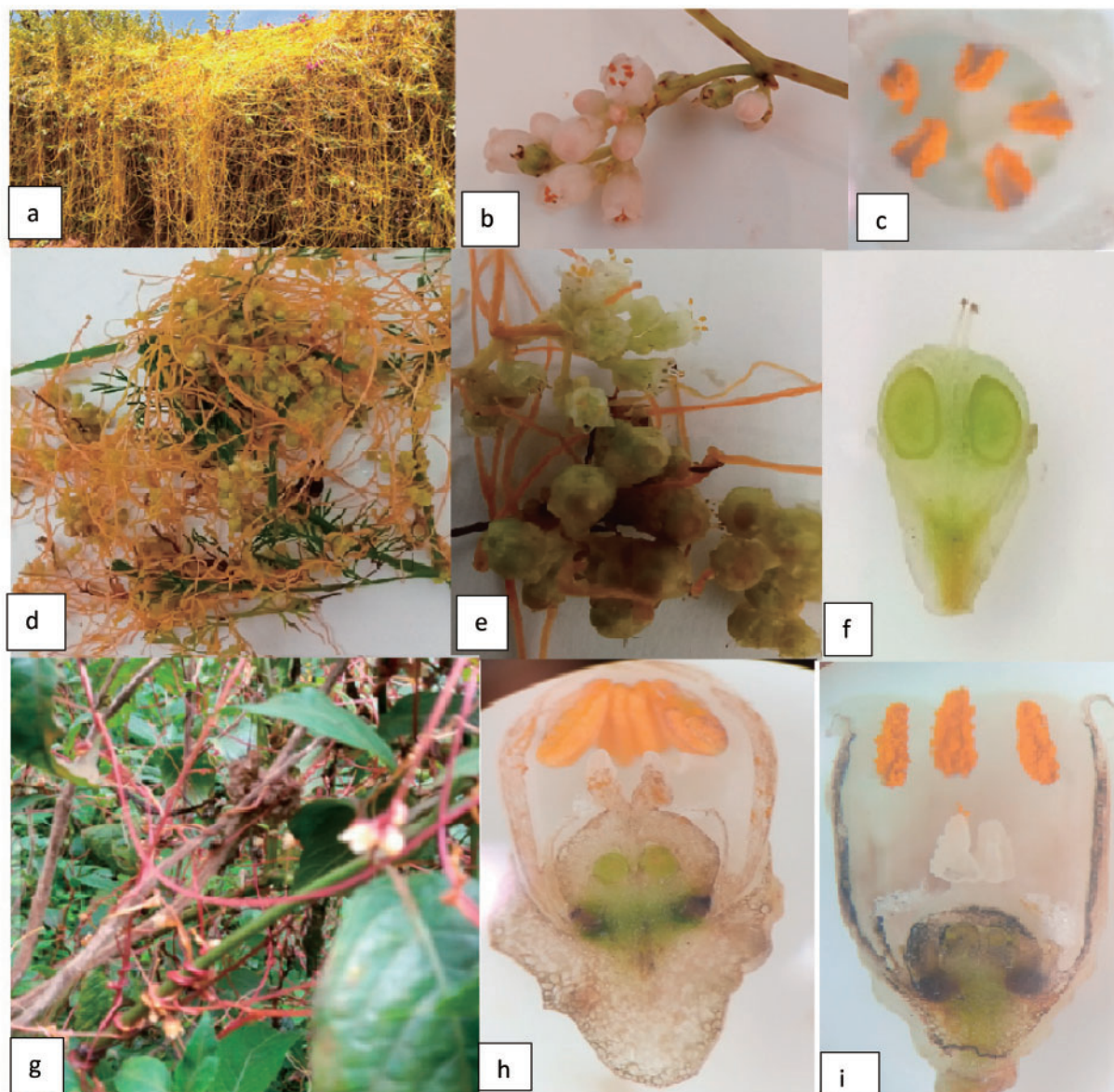


Fig. 1. Morphology of the *Cuscuta* species (a-c, h, i) *Cuscuta reflexa* (a) species, (b) flowers, (c, h, i) anthers, (d-f) *Cuscuta campestris* (d) species, (e) flowers (f) capsule, (g-i) *Cuscuta Kilimanjari* species.

The morphological characters of the three distinct *Cuscuta* species; *C. reflexa* (Kumari et al., 2017; Verma & Yadav, 2018) *C. campestris* (Costea & Tardif, 2006; Mukhtar Irum, 2011; CABI, 2016) and *C. Kilimanjari* are described in Table I and Fig. 1 (Welsh Mark & C., 2010; Costea et al., 2021). *Cuscuta reflexa* showed large flowers with a single thick and short style, 2 elongated stigmas, and ovaries that contained 4 white ovules, of different sizes (Fig. 1). The stem habit showed complete twining to the parasite and develop haustoria at the point of contact with the host with the stamens equals to the corolla lobe numbers. The flowers appear clusters as solitary or in racemose and are small pentamerous. The sepals are five and appear fused, five petals that are united and five stamens that are epipetalous with diverse sizes. The style appears very much reduced with two medially placed carpels showing axile placentation stigma (Sharma & Kapoor, 2014).

Cuscuta campestris comprised slender, threadlike yellow to orange stems (Fig. 1). Flowers were small, and white,

approximately 2 mm in diameter, with greenish-yellow capsules that appeared in dense cymose clusters. Calyx lobes were obtuse, or rather acute, whereas corolla lobes were triangular. The stamens were shorter than the lobes, two separate slender styles, with globose stigmas that did not split at the base and four ovules were present (Fig. 1).

Cuscuta Kilimanjari species was not well distributed across Uasin Gishu County but was found along the forested mountain areas. This species had thick, coarse and purple vines with pale white flowers while the stamens were shorter than the lobes, with short and thick filaments. The styles were two separate short and thick with white stigmas, displaying purple spots in the ovaries (Figs. 1a-i) (Sharma & Kapoor, 2014).

The *Cuscuta* species were diverse with *C. reflexa* exhibiting the widest climatic range. The preference towards a wide environmental conditions is probably related to the cycle of dormancy undergone by the seeds in the soil (Costea & Tardif, 2006). The ecological preferences for temperature and light are recognized for the germination

TABLE I: MORPHOLOGICAL CHARACTERISTICS OF *Cuscuta* SPECIES IN UASIN COUNTY

Character	<i>Cuscuta reflexa</i>	<i>Cuscuta campestris</i>	<i>Cuscuta kilimanjari</i>
Stems	Branched, light brown to dark brown, thick and succulent stem	Branched, thin slender, green to yellow-brown	Branched, purple thick succulent stem
Stem color	Greenish yellow	Yellowish orange	Purplish
Flowers	Large, white to cream, arranged in paniculate cymes, pedicellate, bracts leaf-like	Small white, usually of cymose clusters, actinomorphic	Large, white
Style	Single thick and short	2 separate linear and slender	Short
Stigma	2 elongated and unequal	Capitate or rounded, brown	Round
Calyx lobes	Five, fleshy, margin scarious, rounded, ovate-obtuse, deeply divided, overlapping at the base	Five, obtuse, 5, oval to orbicular	Five
Corolla lobes	Five, ivory white, obtuse, upright spreading, scales scarious	Triangular, oblong- elliptical	Five
Ovules	Four oblong and elliptical	Four, triangular or ovoid; capsule, circumscissile;	Four and oblong
Ovaries	Four white ovules different sizes, conical	Globular, fleshy, brown	
Stamens	Five, Linear filaments, fused	Five	Five
Anthers	Five, fused, oblong, thick,	Five	Five
Capsule	Brown	Globose and membranous	Oblong

and seedling phases, and are virtually unknown for the parasitizing stage. The flowering periods for the three *Cuscuta* species were noted to happen at different times of the year. The flowering time and the survival on the host plant have been shown to be influenced by the appropriate host, temperate, humidity, as well as the movement of hormones responsible for flowering and fruit formation in the host (Tada et al., 1996b; Mishra, 2009). *Cuscuta reflexa* was widely distributed and displayed abundant growth with fast spreading habit and mainly affects woody trees and shrubs. while, *Cuscuta campestris* indulges herbaceous hosts, while *C. kilimanjari* typically parasitizes shrubs and softer parts of trees (Costea et al., 2012; Sharma & Kapoor, 2014). *Cuscuta campestris* and *C. kilimanjari* exhibited narrow range of distribution and restricted mainly to isolated places in Uasin Gishu County mainly in the grassing fields as well as the forested area, respectively.

4. CONCLUSION

Cuscuta species showed tremendous diversity in Uasin Gishu County with *Cuscuta reflexa* exhibiting wide distribution. The morphological variations of the floral morphology are worthy to be taken into account, because it gives us a better understanding of the genetic diversity and easier management strategies.

CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

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