

# A REVIEW OF THE GENUS *TILIA* L. (TILIACEAE) IN IRAN, NEW RECORDS AND NEW SPECIES

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Natural sites were selected as sampling areas in most parts of Hyrcanian forests to study the taxonomical parameters during 2005 – 2010. The range and frequency distribution of *Tilia* trees were studied via searching on the forestry projects and documents, local inquiry and finally controlling the field data towards finding the trees from each forest type during the study period. Corresponding field data included taxonomical details of the specimens and environmental variables. This also accounted for local morphological variation within the different sites of each ecosystem. All studies were performed on living and herbarium specimens, and on some of the most important local herbarium materials. Results of morphological study and biometry of specimens showed that there are clear differences between trees and herbarium specimens. According to summarized data from the obtained results, six distinct species were identified that include: *Tilia cordata*, *Tilia dasystyla*, *Tilia rubra* subsp. *caucasica*, *Tilia begonifolia*, *Tilia sabetii* and *Tilia stellato-pilosa*. Of these six species, the last two species are new to science. Nevertheless variation and presence of these species reveal high degree of diversity of this genus in Iran. To provide new identification key for the species, most important botanical characteristics and their ecology and geographical distributions are described.

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**Key words.** *Tilia*, Hyrcanian forests, new species, Taxonomy, Iran.

مروری بر جنس نمدار در ایران، گزارش‌ها و گونه‌های جدید

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در این مطالعه، تعداد زیادی نمونه درختی از رویشگاه‌های مختلف و نمونه‌های هرباریومی مورد مطالعه قرار گرفت. مشکلات تاکسونومیک فراوانی در رابطه با شناسایی گونه‌های جنس نمدار در ایران وجود دارد، نتایج مطالعات تعدادی از گیاه‌شناسان بر روی این جنس، تنها نمایانگر حضور گونه *Tilia platyphyllos* و در مطالعات برخی گونه *Tilia dasystyla* و در تعدادی هم گونه *Tilia rubra* در ایران است. در واقع نتایج مطالعات اکثر این گیاه‌شناسان، حاصل مطالعه بر روی تعدادی معدود نمونه هرباریومی و نمونه‌های زنده بود و نمی‌تواند منبع کاملی در خصوص قضاوت بر روی نمدارهای ایران باشد. نتایج مطالعه ۶ ساله در این بررسی، نشان داد که گونه *Tilia platyphyllos* در ایران انتشار نداشته زیرا مشخصه مهم این گونه عدم وجود سیخک در نوک دندانه‌ها است که در نمونه‌های نمدار ایران به چشم نمی‌خورد. تعداد گونه‌های نمدار ایران در این مطالعه از ۱ گونه به ۶ گونه افزایش یافت و یک گونه هیبرید (*Tilia xeuclora*) نیز شناسایی شد. تعدادی گونه شامل *T. cordata* و *T. dasystyla*، *T. begonifolia*، *T. rubra* به عنوان اولین گزارش و گونه‌های *Tilia sabetii* و *Tilia stellato-pilosa* به عنوان گونه‌های جدید برای اولین بار نامگذاری و شرح داده می‌شوند. کلید شناسایی جدید، مشخصات گیاه‌شناسی، رویشگاهی و اکولوژی گونه‌ها به همراه شکل و نقشه انتشار آنها نیز ارائه شده است.

## INTRODUCTION

*Tiliaceae* is a family of trees, shrubs or rarely herbs; it includes 400 woody species, among them 30–40 species of *Tilia* that most of them are found in the Asian tropics. Ten species are found in the temperate region of the northern hemisphere (Veličković, 2010). The genus is easily recognized by its unique morphology especially the tongue-like bract to which the stalk of the dichasial cymose inflorescence is partly fused (Pigott, 2006). These trees are widely distributed and locally important members of northern temperate broad-leaved forests (Radoglou et al., 2008). In Hyrcanian forests, they are the most important trees in the forest ecosystems found in northern slopes of Elburz Mountains located in northern Iran. In most regions, especially in Europe, *Tilia* can be found as co-dominant tree species in mixed stands as a result of its vitality and adaptation to the changing environment (Radoglou et al., 2008). But in Hyrcanian forests, the Lime trees (*Tilia* spp.) are large and robust trees with 30 to 40 m. height and 1 to 3 m. in diameter as a dominant tree. Depending on ecological conditions and geographical location, *Tilia* species can be mixed with other broadleaved tree species such as *Fagus orientalis* Lipsky, *Carpinus betulus* L., *Acer velutinum* Boiss., *Alnus subcordata* C. A. Mey., *Quercus castaneifolia* C. A. Mey., *Parrotia persica* (DC.) C. A. Mey. as well as a needle leaved species such as *Taxus baccata* L.

The genus *Tilia*, due to many taxonomic problems and difficulty in specimen collection of tall trees and because of being spread, has always been an interesting tree species to study. The species, however, are difficult to determine. More than one hundred has been described but evidences, which are largely based on recent studies on natural populations, supplemented by chromosome counts and cultivation, indicate a much lower number: probably 22 species with 12 subspecies (Pigott, 2002). Since many of vegetation and ecological features of Hyrcanian forests are unknown and the forests are old and because of natural obstacles have remained safe from the last glacial era, they become a refuge for many broad-leaved species in such a way that most of these species have been vanished from the forests in Europe and the Caucasus and, during this period, they had the opportunity to develop (Takhtajan, 1986).

Hence, more study on plant taxonomy and phytogeography investigation of Hyrcanian forest can manifest many unknown features. There is poor taxonomic information on the genus *Tilia* relating to Iran and the last study in the Flora Iranica was previously revised by Browicz (1981). In this study, one species with two subspecies were accepted (Browicz, 1981). Studies related to Iran's *Tilia* were

mainly affected by studies done on herbarium specimens by foreign botanists like Browicz (1981), Pigott and Francis (1999). In spite of a few studies done in the past, the fact of the presence of different species has been neglected.

## MATERIALS AND METHODS

The study area includes Golestan, Mazandaran and Gilan provinces in the north of Iran. From East to West and also in altitudinal range of lower and mid-altitude to the upper parts of northern slopes of Alburz mountains with approximate geographic coordinates: 35° 49' to 38° 40' N, 48° 55' to 56° 57' E in the forest zone of Hyrcanian province of the Euro-Siberian region. This zone consists of different geographical aspects and wide range of mountainous sites, altitudinal range is between -20 to 2600 m above sea level. The annual temperature of this area ranges from -5 to 12.6°C during winter to 18 to 35°C during summer, with rainfall ranging from 770 mm. in the Eastern, to 2200 mm. in the Western parts.

The range and frequency distribution of *Tilia* trees were studied via searching on the forestry projects and documents, local inquiry and finally controlling the field data towards finding the trees from each forest type during the study period. Afterwards natural sites were selected as sampling areas in most parts of Hyrcanian forests to study the taxonomical parameters during 2005 – 2010. Corresponding field data included taxonomical details of the specimens and environmental variables (habit, phenology, abundance, habitat, latitude, altitude, and soil type and plant associations). This also accounted for local morphological variation within the different sites of each ecosystem. Moreover, sampling exploration was made in the study area and it included nearly every month of the growth period in order to collect specimens through the use of trained workers to take samples from large trees. From each tree in the population, 8-10 specimens were collected. All studies were performed on living and herbarium specimens, and on some of the most important local herbarium materials. Specimens of the largest Iranian herbaria including TARI, TUM and herbarium of Swedish Museum of Natural History as well as some of the most important local herbaria were studied. In this way, data from herbarium materials associated with investigation on living specimens are used to extend the morphological studies and also to compare them with large herbarium specimens. A number of morphological observations applied to determine the variation of organs consist leaves shape, size and configuration of lateral teeth and the tip of the leaves, the presence or absence of prod (aristate) on the tooth,

hairs and type of them on the surface and below the leaves, hair tuft on axillary veins, being hairy and pubescence on the vein, petiole, flowering bracts, peduncle and pedicels, flowers, length of peduncle and pedicels, pubescent or glossy styles and existence of staminod, fruit shape and being plain or presence of rib on the surface of fruits, traits of fruits such as symmetry and situation of the rib and tip.

The study also intend to describe some ecological traits of the different trees of the *Tilia* spp., to identify the various taxonomical characteristics of the taxa in relation to provide conclusions for detailed judgments via using extensive data from field studies and natural populations in the sites with different ecological characteristics. Furthermore, looking at the entire plant such as young specimens, sprouts and strong shoots gives an atypical view for correct judgment compare with typical vegetative and generative organs of *Tilia* trees that can constantly be study as the main selection and also considering the position of samples and trees in the forest stands and quality of the habitat.

## RESULTS

The seven-year study on trees in the fields and collecting numerous herbarium specimens led to the accurate judgment to determine specimens. Hence, we had to elaborate some morphological traits of the genus *Tilia* in Iran to evaluate and solve taxonomic issues.

Results of morphological study and biometry of specimens showed that there are clear differences between trees and herbarium specimens. Despite, according to summarized data from the obtained results, six distinct species were identified that include: *Tilia cordata* Miller, *Tilia dasystyla* Steven, *Tilia rubra* DC. subsp. *caucasica* (Rupr.) V. Engler, *Tilia begonifolia* Steven, *Tilia sabetii* Zare and *Tilia stellato-pilosa* Zare, Amini & Assadi. Of these six species, the last two species are new to science. Nevertheless variation and presence of these species reveal high degree of diversity of this genus in Iran. To provide new identification key for the species, most important botanical characteristics and their ecology and geographical distributions are described.

### Key to *Tilia* species in Iran (Fig. 1.)

1. Underside of leaves and other plant parts invariably covered with only bright brown stellate hairs

#### 6. *T. stellato-pilosa*

- Underside of leaves and other plant parts often glabrous or with outspread simple or stellate hairs 2  
2. Leaves dense, relatively small and its length less than 9 cm; veins on lower leaf surface less prominent, more or less oblique. Fruit shell soft (subcoriaceous)

#### 1. *T. cordata*

- Leaves distant, relatively large and its length more than 10 cm; veins on the lower surface prominent, relatively parallel. Fruit shell tough and woody 3

3. Underside of leaves especially on the sprout and young shoots simultaneously with simple and scattered stellate hairs, rarely glabrous 4

- Underside of leaves glabrous or with scattered simple hairs 5

4. Leaf length and width approximately equal, slightly oblique - Throughout of style or close to stigma pubescent, or  $\pm$  glabrous

#### 2. *T. dasystyla*

- Leaves especially on the upper and flowering shoots longer than broad, strongly oblique. Style glabrous

#### 4. *T. begonifolia*

5- Pedicel up to 13 cm long. Peduncle elongate, 5-7 cm long Floral bract broad with different shape, 2-3 times longer than broad. Fruit asymmetric with long point (cusp)

#### 5. *T. sabetii*

- Pedicel 6-7 cm long. Peduncle short, 2-3 cm long. Floral bract elongate, 4-5 times longer than broad. Fruit symmetric and without long point

#### 3. *T. rubra*

1. *Tilia cordata* Miller, Gard. Dict. Ed. 8, no. 1 (1768), Figs. 2 & 8.

Ic: Hegi, 1954 (1925), III. Fl. Mittel.-Eur. 5 (1):438, f.

Tree up to 35 m. Crown outspread to broadly ovate. Bark of young trees smooth, in old trees furrowed, dark gray; lower parts of trunk often abounding sprouts; young twigs short, with plenty of buds and relatively zigzag form, usually smooth, at first tiny pubescent, becoming glabrous; upper side of shoots red and lower parts pale green with plenty lenses; buds ovate, obtuse, yellow-brownish and in winter red. Leaves rounded or sub orbicular, cordate at base and relatively equilateral, rarely oblique, abruptly long-acuminate, length and width almost equal, 3-9 cm long and 2.5-8.5 cm broad, often smaller than other species, margin singly or doubly serrate, antrorse or against, obtuse or acuminate with arista, glossy dark green and glabrous above, pale green to glaucescent, glabrescent except for scattered hairs on veins and with light brown (rufous) axillary tufts. Petioles 1.5-4 cm long, glabrous, greenish yellow. Inflorescence 3-9 flowered or more, whitish yellow, fragrant; peduncle 4-7.5 cm, pendulous; bracts upright, 3.5-8.5 cm long and 1-1.5 cm broad, often smaller than others; sepals cymbiformis or ovate, pointed, exterior glabrescent and inside pubescent, 3-4.5 mm long; petals longer than sepals, 6 mm long, narrowly elliptic; style glabrous; stamens numerous, longer than petals. Flowers open later than other species. Fruits often globose, sometimes slightly ribbed, rather tomentose only at first, 4-8 mm long, thin-shelled, breaks easily.



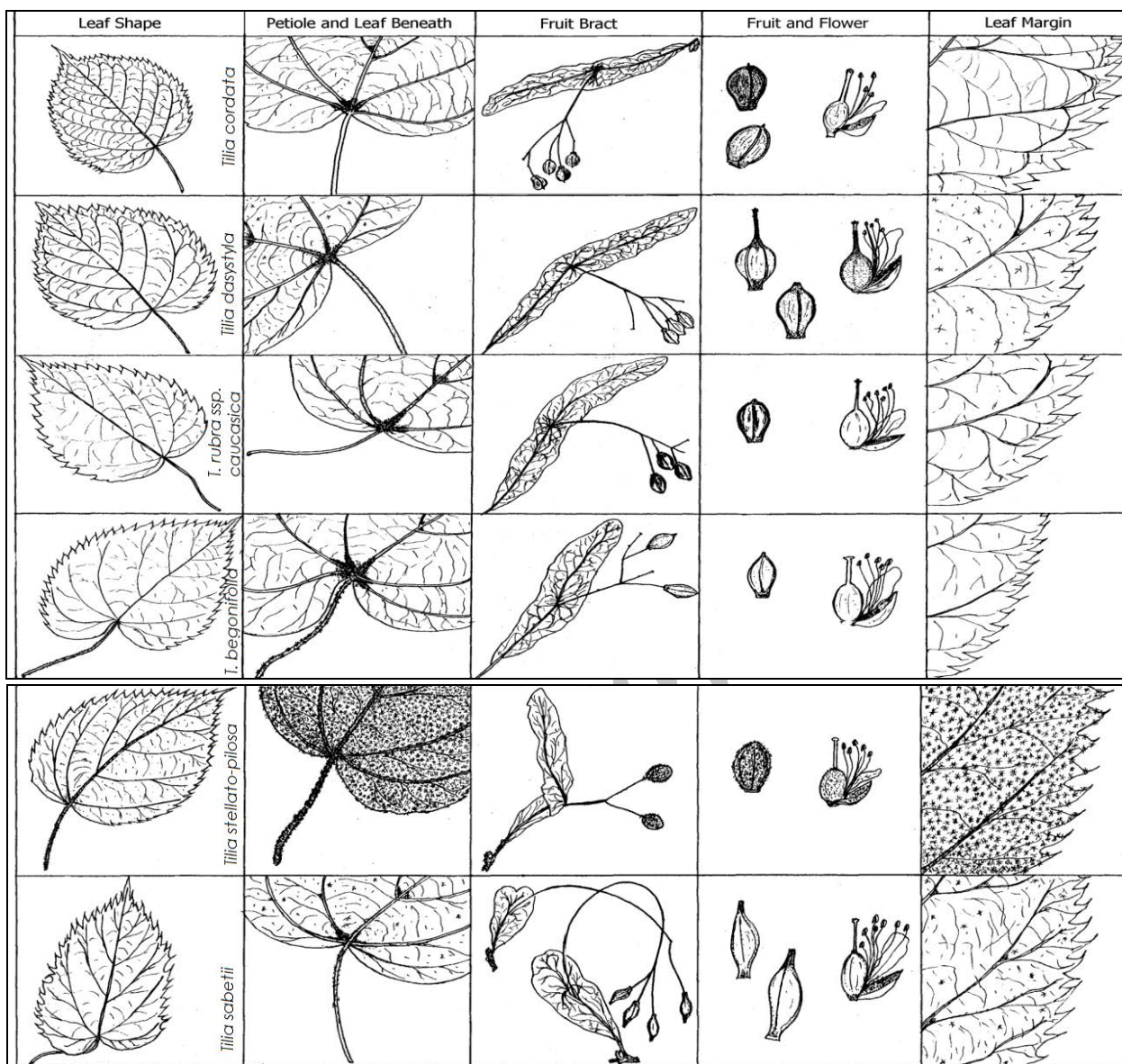


Fig. 1. Comparative Table of *Tilia* spp. in Hyrcanian forest by shape.

**Mazandaran:** Sari, Dodangeh region, Partkola, Ezhgheh forest, 1800 m, Zare, 10160; same locality, Noosang forest, 1400 m, Zare, 10159; same locality, Unjimeh forest, 1100 m, Zare, 10573; Amol, Haraz valley, road to Baladeh, Lasikoo forest, 1300 m, Zare, Naseri and Rezaee, 10587; same locality, 1700 m, Zare, Naseri and Rezaee, 10536; Nowshahr, Botanical garden, -20 m, Zare, 7870, Same locality, -20 m, Zare, 7885, Same locality, -20m, Zare, 7881; Nowshahr, Chalandar forest, 80 m, Zare, 10158; Chalous, road to Kandavan, between Dezdeben and Naharkhoran, 700 m, Zare, 7869.

**2. *Tilia dasystyla* Steven, Bull. Soc. Nat. Moscou 4:**

260 (1832), Figs. 3 & 8.

*Tilia dasystyla* Steven is a low range species in Hyrcanian forests. In many references, northern Iran and the Caucasus have been mentioned as its origin habitat (Pigott, 1999). Pubescent style and short teeth at margin are obvious characteristics that can separate this from *Tilia rubra* and *Tilia xeuchlora*.

Tree up to 35 m and more than 1 m in diameter, broadly pyramidal. Stem cylindrical; bark of stem dark brown, with deep slots. Young twigs red-brownish at first, sometimes with blue dust, smooth or with scattered simple or stellate hairs; young leaves thin, then relatively firm and leathery, broadly ovate or sub-

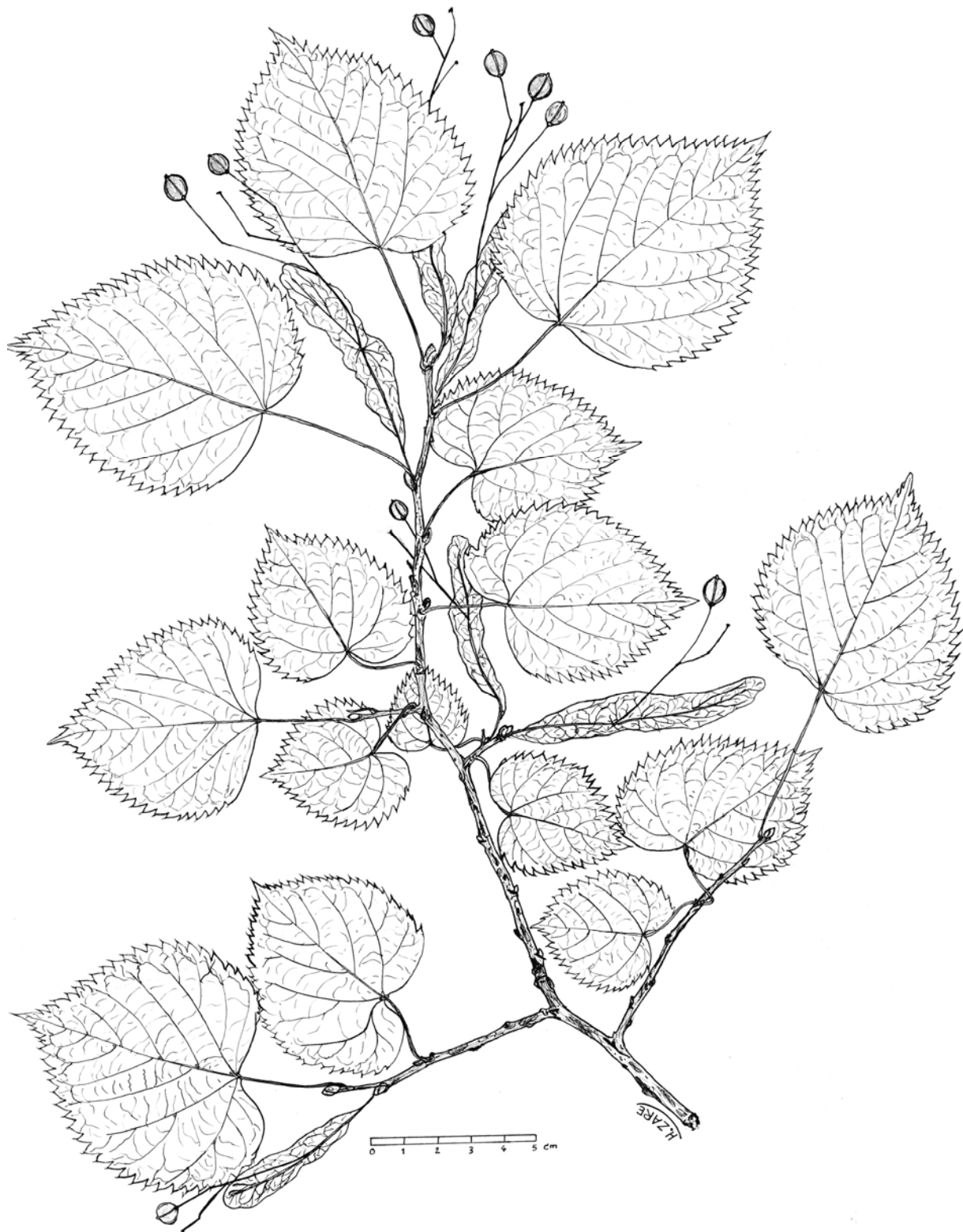


Fig. 2. *Tilia cordata*.

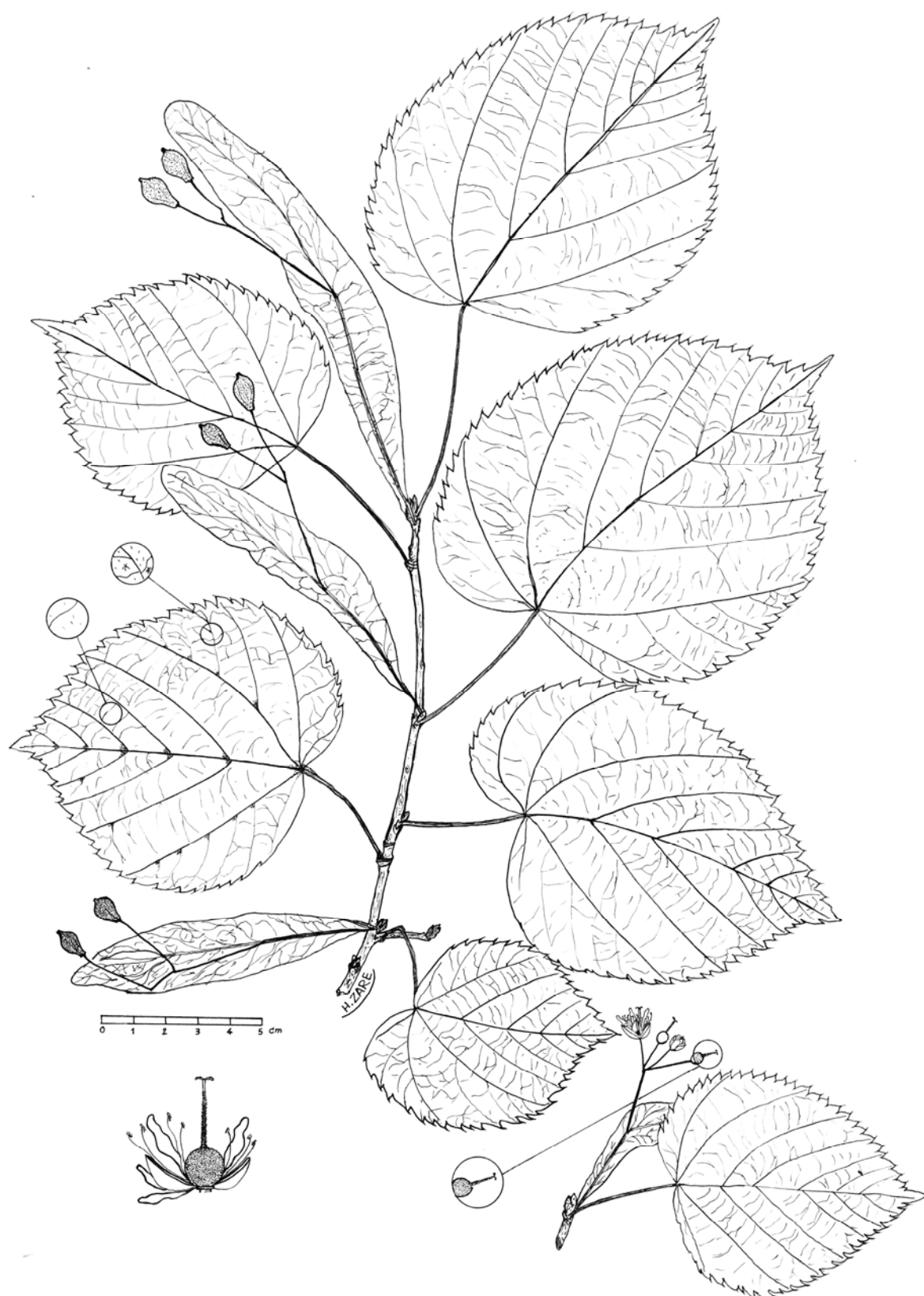


Fig. 3. *Tilia dasystyla*.

orbicular, short-acuminate at apex, cordate and broadly rounded at base somewhat oblique, margin with small teeth and shortly aristate, dark green and  $\pm$ lustrous above, under of leaves light green, glabrescent or sparsely pubescent with simple or stellate white hairs; veins prominent, with reddish hairs in angles between veins, sometimes along the veins; petiole firm, 2-4 cm long. Inflorescence 3-7 flowered, often erect; bracts 3.5-11 cm long and 1-3 cm broad, firm and leathery; stalk 5-10 mm long; petals narrowly elliptic, 6-8 mm long, lustrous yellow; sepals broadly triangle, pubescent at margin, inside covered with dense and long white hairs; style 3-5 mm long, densely pubescent throughout or close to the stigma. Fruit narrowly elliptic, apiculate at apex and with persistent style, 8-12 mm long and 6-8 mm broad, hard woody shell, relatively prominently 5-ribbed, densely brownish-pubescent, on bract usually 3.

**Mazandaran:** Sari, Dodangeh region, Sangdeh, Boola forest, Asiabkaleh, 2400 m, Zare and Amini, 7872; Nowshahr, km 17 to the East, *Buxus hyrcana* forest between Chelak and Chalandar, 50 m, Zare, 10432; Nowshahr, km 11 to the East, between Mazga and Dozdak, 70 m, Zare and Amini, 10479; Chalous, road to Kandavan, before Dezdeben, 700 m, Zare, 10463; same locality, 900 m, Zare, 10550.

### 3. *Tilia rubra* DC., Cat. Pl. Hort. Monsp. 130(1813).

*Tilia rubra* is similar to *Tilia platyphyllos*. There are reddish shoots, glabrous leaves, with aristate teeth margin and narrowly rectangular floral bracts in *Tilia rubra* whereas in *Tilia platyphyllos*, teeth are not aristate and both surfaces of leaves are more or less pubescent. *Tilia platyphyllos* is not distributed and is different from other species that are present in Iran. The main habitat of *Tilia platyphyllos* is central, northern and western parts of Europe and the easternmost range is south-west and north-west of Turkey. Therefore, it seems impossible to assign it to Hyrcanian phytogeographical range.

subsp. **caucasica** (Rupr.) V.Engler, Monogr. *Tilia* 107(1990), Figs. 4 & 9.

Syn: *Tilia caucasica* Rupr. Fl. Cauc. 253 (1869). *Tilia platyphyllos* scop. subsp. *caucasica* (Rupr.) Loria, Bot. Zurn. S.S.S.R. 52. 12: 1790 (1967).

Large tree, 30-40 m height and up to 2 m in diameter; crown rounded or narrowly elliptic; bark of trunk grayish with longitudinal fissure; young shoots red, glabrous, yellow-brownish at first, gradually dark brown and shiny red. Winter buds 7-10 mm long, ovate, brown-reddish. Leaves relatively leathery, broadly ovate or slightly narrow, 4-13 cm long and 5-13 cm broad, often its length is equal to width, in sterile

shoots larger, varied in base, rounded to cordate, slightly oblique, apex gradually decrescens or abruptly acuminate, margin serrate, triangle teeth aristate, glabrous and light green, slightly lustrous above, paler and glabrous beneath, exclusive of long and scattered hairs on main veins, with green-white or tawny pubescent in axillary tufts or rarely without it; petiole glabrous, 2.5-5 cm long, yellow-brownish. Inflorescence 3-7 flowered, pendulous; floral bracts glabrous, narrowly rectangular, 6-13 cm long, stalked or sessile; flowers light yellow; petals elliptic and longer than sepals, 6-7 mm long; sepals 5-6 mm, glabrous on the outside, inside with long and sparse hairs; stamens longer than perianth; style glabrous, 7-8 mm long. Fruit obovoid, subglobose to elliptic or slightly elongate, 9-13 cm long, densely short tomentose or sparse, rather with 5 prominently nerved, hard woody shell.

**Golestan:** Zarringol, 520 m, Riazi, 8632; Aliabad, 20 km road to Shahrood, 600 m, Zare, 10575;

**Mazandaran:** Sari, Dodangeh region, Partkola, Noosang forest, 1750 m, Zare and Amini, 10582; same locality, 1570 m, Zare and Rezaee, 7879; same locality, Ezhgheh forest, 1800 m, Zare and Rezaee, 10554; Sari, Dodangeh region, Kalijkola, 1000 m, Zare, 7873; Polesefid, Sangdeh, Ashek forest, 1600 m, Assadi, 73579; Amol, Haraz road to Baladeh, Lasikoo forest, 1800 m, Zare, Rezaee and Rasooli, 10583; Noor, Lavidje forest, 700 m, Zare and Rezaee, 10555, same locality, 750 m, Zare and Rezaee, 10546, Nowshahr, *Buxus* forest of Chelak, 250 m, Zare, 7871; Nowshahr, Urban Park, -20 m, Zare, 10466; Chalous, Kandavan road, between Hezarcham and Dezdeben, 1400 m, Zare, 10527; same locality, Naharkhoran rocky forest, 1550 m, 10533; **Gilan:** Hashtpar, Lisar valley, 690 m, Roshan, 8627; Asalem, 1120 m, Rahmani, 8630.

### 4. *Tilia begonifolia* Steven, Bull. Soc. Nat. Mosc. XXIX (1857), Figs. 5 & 9.

*Tilia begonifolia* is distributed in Hyrcanian forest and is closely related to *Tilia rubra*, but differs mainly in the narrowly elliptic or elongate leaves, strongly oblique at base, petiole with stellate hairs and elongate fruits. Whereas in *Tilia rubra* leaves are broad-ovate, often its length is equal to width, rounded to cordate at base, slightly oblique, petiole glabrous and fruit obovoid, subglobose to elliptic or slightly elongate. Their habitats are usually similar and sometimes they are mixed and associated.

Tree, up to 35 m tall and 2 m in diameter; crown ovate; bark of young tree streaky and spotter, grayish, in old trees with relatively deep slots, dark gray to brown, in shoots brown-reddish, glabrous, rarely pubescent.

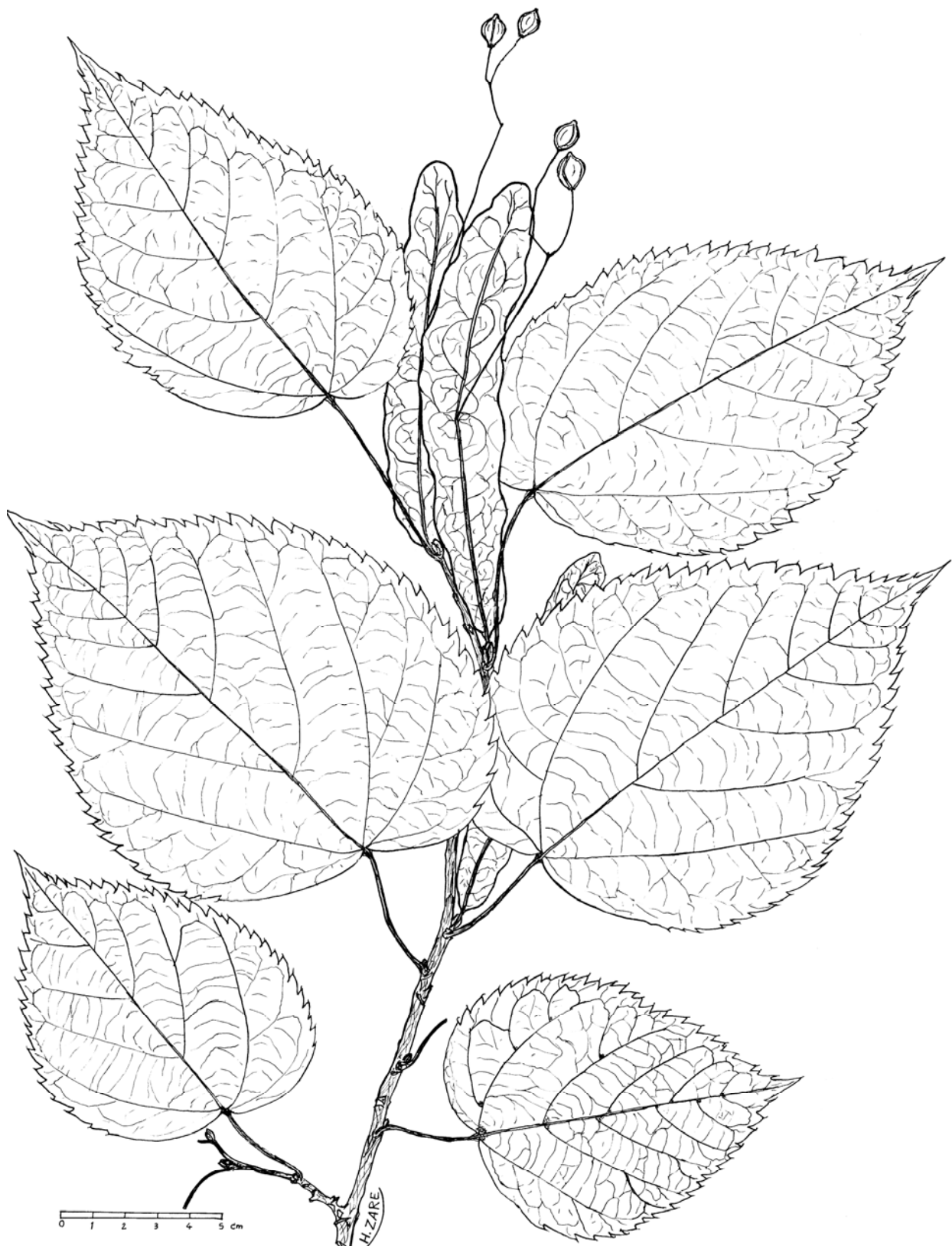


Fig. 4. *Tilia rubra* subsp. *caucasica*.



Leaves narrowly ovate to elliptic, mostly longer than width, especially on the upper parts of trees and fertile twigs (flowering shoots), 8-13 cm long and 6-10 cm broad, relatively shortly acuminate (never abruptly acuminate), cordate and strongly oblique at base, sometimes quite angled in one side or often round, margin serrate with aristate teeth, dull green and glabrescent above, light green and glabrous except scattered white hairs on main and secondary veins, often with yellowish and permanent axillary tufts. Petiole 3-6 cm long, covered with dense or scattered stellate hairs, sometimes extended in the axillary veins on above or without it. Inflorescence 3-6 flowered, on the large bracts with 5-13 cm long and 1-2.5 cm broad on a stalk 0.5-2.5 cm; sepals densely pubescent on the inside and margin; style relatively long and glabrous. Fruits ovate or narrowly elliptic, with hard woody shell, 9-14 mm long, with prominent ribs, covered with light yellow to grayish hairs, sometimes with persistent style.

**Golestan:** Gorgan, km 15 road to Kordkuy, 650 m, Assadi and Hemmati, 88834; **Mazandaran:** Pole-Sefid, Sangdeh, 1500-2000 m, Assadi, 73500; Sari, Dodangeh, Sangdeh, Boola forest, Pashtelat, 2400 m, Zare, 10537; Sari, Dodangeh, Partkola, Sangenoo forest, 1570 m, Zare and Rezaee, 789; Amol, Haraz road to Baladeh, Lasikoo forest, 1680 m, Zare, Rezaee and Naseri, 10587; Chamestan, Research station of Chamestan, plantation site, 70 m, Zare and Amini, 10460; Alamdeh (Rooyan), 5 km on road to Kojur region, 110 m, Runemark and Mozaffarian, 28126; Nowshahr, Andarvar village, 100 m, Sabeti, 8629; Nowshahr, Kheirood kenar, 0-200 m, Assadi, 33739; Chalous, between Hezarcham and Dezdeben, 1400 m, Zare; Ramsar, 20 km to Jannat-Rudbar, 1250 m, Maassoumi and Runemark, 21595.

5. *Tilia sabetii* Zare, **sp. nov.**, Figs. 6 & 10.

Arbor usque ad 20 m alta; truncus 70-80 cm diametro, cortice juvenile nitido  $\pm$  fissurato; rami juveniles glabri, fusci vel pallide virides, lentibus frequentibus. Hibernacula anguste ovata. Folia 5-13 cm longa, 4-9 cm lata, anguste ovata, apiculata,  $\pm$  oblique cordata, margine manifeste aristato-serrata, supra pallide virides, glabra, subtus flavo-virens, pilis simplicibus vel stellatis praediti, demum evanescentibus. Cymae pendulati, 1-5 florum; bracteae, 5-10.5 cm  $\times$  2-3.5 cm, variabiles, ad basem attenuati, apice dilatati; pedunculi longissimi, 4.5-7 cm longi; pedicelli ad 13 cm longi. Sepala carinata, dilatata, extus glabra, intus pilosa. Petala oboidea, fragrantia. Stylus glaber. Fructus ovalis, asymmetricus, 15  $\times$  7 mm, longe cuspidatis et  $\pm$  curvatis, 5-costatus, pilosus, ligneus sed fascile frangens.

*Typus.* Iran, Mazandaran, Chaloos, Kandavan road, rocky forests between Naharkhoran and Hezarcham, 900 m, Zare & Amini 10161 (holotypus TARI); Chaloos, Kandavan road, Hezarcham forests, 1500 m, Zare & Amini 10586; Chaloos, Kandavan road, rocky forests between Dezdeben and Naharkhoran, 1150 m, Zare & Amini 7878; Chaloos, Kandavan road, Naharkhoran, 1100 m, Zare & Amini 7869; Chaloos, Kandavan road, Hezarcham rocky forests, 900 m, Zare & Amini 8140.

Tree up to 20 m high and 80 cm in diameter; bark of young trees smooth and gray, gradually shallow fissured; shoots smooth and dark brown or pale greenish and with many prominent lenticels; winter buds narrowly ovate, bright green to brown, scaling tip with white hair. Leaves narrowly ovate, apiculate at apex, relatively cordate and often oblique at base, 5-13 cm long and 4-9 cm broad, upper surface pall green, glabrescent, below bright green with simple and stellate scattered white hairs, gradually wanting, margin with triangular aristate teeth. Petiole long, 3.5-7 cm, at first with stellate hairs then without. Cymes pendulous; bracts with variable size and shape, 5-10.5 cm long and 2-3.5 cm broad, tapering at the base, broadened to the apex, larger and broader than the other species, sometimes depleted and as a spread sheet; bract stalk 1.5-2 cm long, flowers 1-5, peduncle very long, 4.5-7 cm, pedicel up to 13 cm long; sepal cymbiforme (boat-shaped), outside glabrescent and inside pilose; petals oval, fragrant; stamens longer than style and perianth; style glabrescent. Fruits asymmetric and narrow oval, with long point or cusp and relatively curved, ribs 4-6, relatively prominent; the fruit cross-section at base is obviously pentagons, up to 15 mm long and 7 mm in diameter, covered with very small hairs, slightly curved at tip, dark gray, woody and not easily broken. Bracts usually with 1-3 ripe fruit. Flowering period is later than the other species and often simultaneously with *Tilia cordata*.

*Affinity.* *Tilia sabetii* is similar to *Tilia rubra* but differs by having bracts with variable shapes including narrow and long or broad and short, with very long peduncle up to 7 cm. and pedicels up to 13 cm, asymmetric narrow oval fruits with long point or cusp. Whereas in *Tilia rubra* floral bracts are narrowly rectangular, peduncle shorter than 4 cm. and pedicel 6-7 cm., fruit symmetric, obovoid, subglobose to elliptic and without long point or cusp.

*Ecology and Biogeography.* *Tilia sabetii* is distributed in central Elburz region, south of Chaloos (Chaloos valley and Kandavan road to Tehran), and a part of the mountainous Hyrcanian forests zone. Altitudinal distribution range of this species is generally between

900 -1500 m. a.s.l., from Dezdeben the lowest altitude to Hezarcham, the highest one with rocky site and shallow soil layers in transitional zone of highland forests where this species is mixed with *Acer campestre* L., *Acer hyrcanum* Fisch & C. A. Mey, *Acer monspessulanum* L. subsp. *ibericum* (M. B.) Yaltirik. *Fraxinus excelsior* L. subsp. *coriariifolia* (Scheele) E. Murray, *Celtis caucasica* Willd., *Tilia* spp., *Carpinus orientalis* Miller, *Quercus petraea* L. ex Ehrh. subsp. *iberica* (Stev.) Krassiln., *Berberis integerrima* Bge. *Cotoneaster* spp., *Viburnum lantana* L., and forbs and other plants including *Thalictrum minus* L., *Polygonatum orientale* Desf. *Circium osseticum* (Adams) Petrak subsp. *osseticum*, *Centaurea kandavanensis* Wagenitz, *Allium paradoxum* (M. B.) G. Don., *Achillea millefolium* L. subsp. *millefolium*, *Brachypodium pinnatum* (L.) P. Beauv. and *Briza media* L.

The distribution range of *Tilia sabetii* is very limited and narrow. It grows on cliff and rocky sites from margin of Chaloos river to upper part of Hezarcham mountains. *Tilia sabetii*, because of severe conditions including shallow soil and cliffy sites, is a medium-size tree in this site. Nevertheless, the site is rather humid with enough precipitation especially in growth periods and may control the severe conditions regarding the limitation of soil physical characteristics.

**6. *Tilia stellato-pilosa* Zare, Amini & Assadi, sp. nov., Figs. 7 & 11.**

Arbor usque ad 35 m alta; truncus 120 cm diametro, cortice longitudine sulcato, fusco; rami stellato-pilosi, aurei, vetustiores puberuli, lentibus frequentibus, hornotini brunei; hibernacula anguste ovata, brunnea. Petiola 3-4.5 cm longa, stellato-pilosa; laminae 6-10 cm x 4-7 cm, late ovatae ad  $\pm$  cordatae, ad bases oblique cordatae, apice acuminatae vel apiculatae, margine irregulariter dentibus triangularibus, serratae vel crenatae, aristatae, supra atrovirentes, basin versus et secus nervos stellato-pilosi, subtus pallide viridi vel aurei, uniformiter stellato-pilosi; petiolus 3-4.5 cm longus, dense stellato-pilosus. Cymae pendulae, 3-5 florum; bracteae 7-9 cm longae, 1-1.5 cm latae, anguste oblongae, stipitibus 8-27 mm. longis. Sepala lanceolata, intus pilosa. Stamina petala superantes. Stylus glaber. Fructus 7-11 mm longus, globosus, ellipticus, ovatus, apice obtusus, prominenter 4-6 costatus, stellato-pilosus, pilis laete bruneis.

*Typus.* Iran, Mazandaran, 70-80 km S. Sari, Dodangeh, Partkola village, Sangenoo forest to Ezhgheh, 1750 m, Zare & Amini 10647 (holotypus TARI); the same area, Ezhgheh forest, 1850 m, Zare & Amini 10644.

Tree up to 35 m. high and 120 cm. stem diameter; bark

with deep longitudinal grooves, gray-brown; young twigs covered with dense and golden stellate hairs; branches dark green when young, gradually changing brown along with the appearance of lenticules; winter buds ovoid, dark brown. Leaves relatively small, ovate or  $\pm$  cordate, 6-10 x 4-11 cm, acuminate to apiculate at the apex, symmetrically cordate (oblique), at the margin serrate, with short triangular teeth or crenate with short arista at the tip, dark green and slightly shiny, near the base specially on veins sometimes covered with stellate hairs, on the underside except for bright brown simple hairs in the vein axils light green to golden yellow, permanently and uniformly covered with stellate hairs; petiole 3-4.5 cm long, covered with permanent and dense stellate hairs. Cymes 3-5 flowered, pendulous. Bracts long rectangle, 7-9 x 1-1.5 cm, with stalk, 8-27 mm long. Sepals pilose inside. Stamens as long as sepals and petals, Style glabrous. Fruit 7-11 mm. long, obtuse at the apex, with 4-6 relatively prominent nerves, covered with stellate and bright brown hairs, woody and not easily broken.

*Tilia stellato-pilosa* is a new species distributed in Dodangeh forests South of Sari. This species seems to be related to *Tilia dasystyla*, but permanently and invariably covered with bright brown stellate hairs on the plant organs including leaves, petioles, young shoots, peduncle and fruits. In addition, yellow-brownish color of the underside of the leaf, globose fruits covered with relatively long stellate and curved brown hairs make it distinguishable from the other species of *Tilia*, especially *Tilia dasystyla*.

*Ecology and biogeography.* *Tilia stellato-pilosa* is distributed in eastern parts of central Hyrcanian forests in Dodangeh region, located in 70-80 km south of Sari (Mazandaran province). Altitudinal distribution range of this species is generally above 1500 m. a. s. l., especially between 1750 and 1850 m. in southern forests of Partkola village in Ezhgheh and Sangenoo forests. This species is present in *Fagus orientalis* Lipsky association along with *Carpinus betulus* L., *Sorbus torminalis* (L.) Crantz, *Acer mazandaranicum* Amini, Zare & Assadi, *Acer velutinum* Boiss., *Acer cappadocicum* Gled, *Cerasus avium* (L.) Moench and *Alnus subcordata* C. A. Mey. Understory layer is covered with shrubs, forbs and the others viz. *Hypericum androsaemum* L., *Ilex spinigera* (Loes) Loes, *Crataegus microphylla* C. Koch., *Atropa belladonna* L., *Tanacetum parthenium* (L.) Schultz-Bip., *Lapsana communis* L., *Sedum stoloniferum* S. G. Gmel., *Festuca drymeia* Mert. & Koch, *Brachypodium sylvaticum* (Huds.) P. Beauv., *Epipactis helleborine* (L.) Crantz., *Cephalanthera caucasica* Kranzl and *Calamintha grandiflora* (L.) Moench. *Tilia stellato-pilosa* grows in humid sites with high

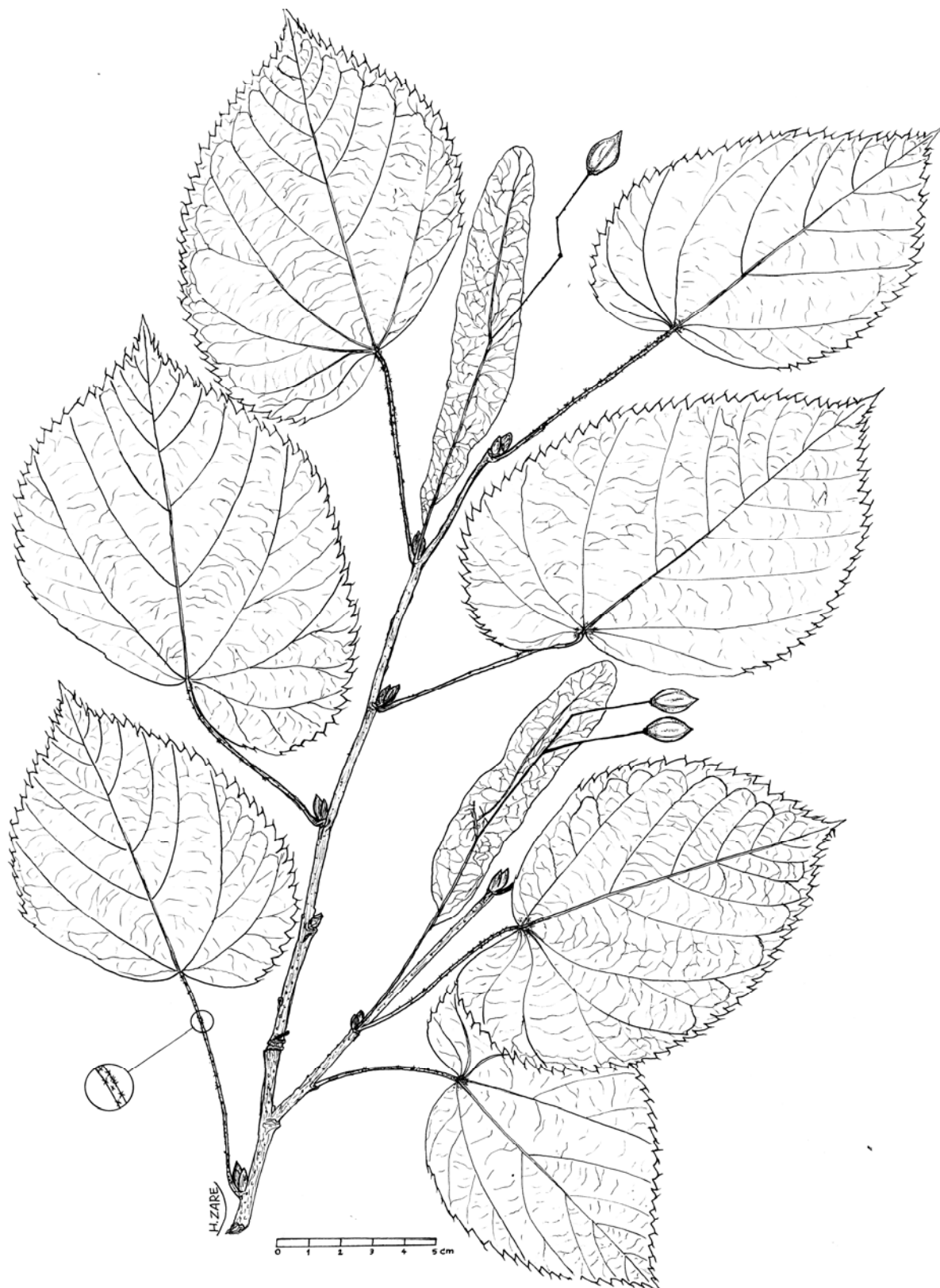


Fig. 5. *Tilia begonifolia*.

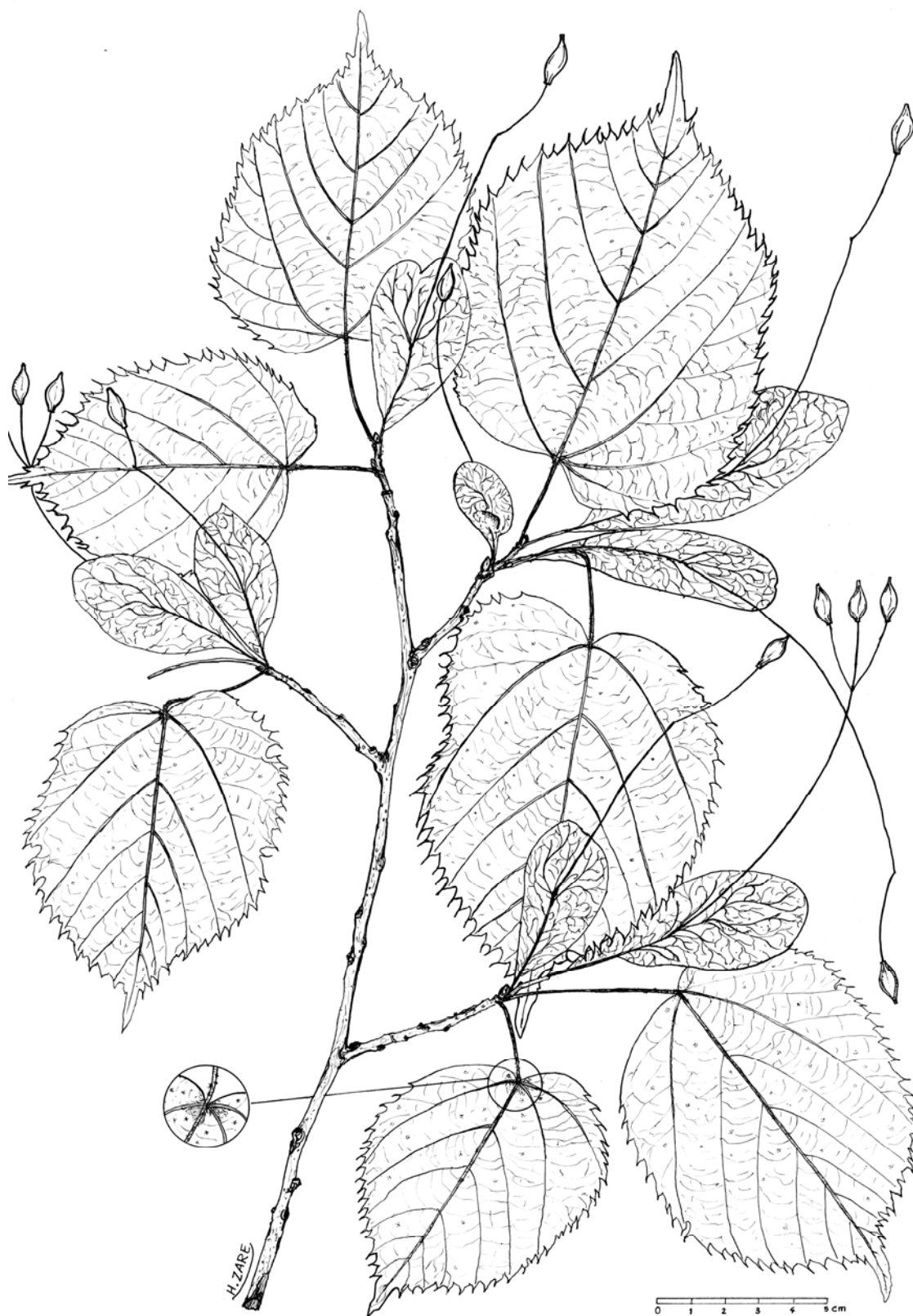


Fig. 6. *Tilia sabetii*.

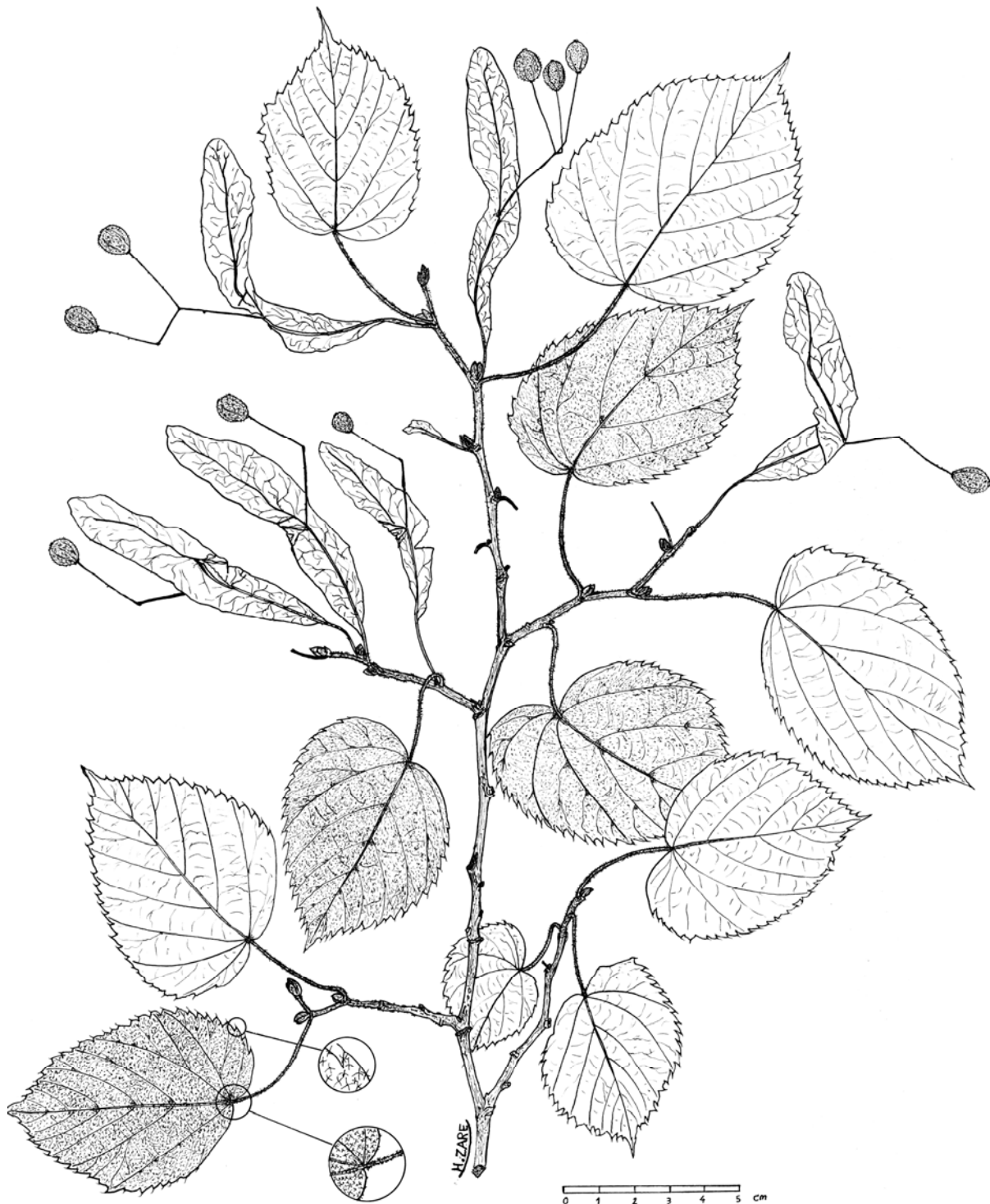


Fig. 7. *Tilia stellato-pilosa*.



precipitation and relatively foggy conditions in most of the times especially in the summer. It prefers wet soils with well drainage, generally north and east slopes with high hummus layer and sometimes rocky sites. This species is shade-tolerant and when reaches to mature stage, it needs the sites with direct light penetration. Its stem has a cylinder form with relatively deep furrowed bark. From a far distance, mature trees seem yellowish and when compared with the other trees, they are easily recognizable.

### Hybrid

*Tilia* × *euchlora* C. Koch, Wochenschr 9: 284 (1866); Ind. Sem. Hort. Berol. app. 1. 9 (1867). (*T. cordata*? × *T. dasystyla*?)

A medium tree that typically grows to 30-35 m. Leaves ovate to rounded, glossy deep green with acuminate tips and irregular cordate bases. Style short and usually bottom of the style covered with rather long and dense hairs. The seeds are slightly ribbed but usually sterile.

### DISCUSSION AND CONCLUSION

As previously mentioned, there is not a unique agreement among the botanists in exact identification of *Tilia* species, so there can be found numerous names in the literature e.g. 23 (Pigott, 1969, 2002), 25 (Tang & Zhung, 1996) and 30 species (Krussmann, 1986 & Radoglou, 2008). Sabeti (1976) introduced *Tilia begonifolia* to the flora of Iran and named two other species from the Chaloos valley as *Tilia* sp. Djavanshir (1976) introduced *Tilia dasystyla* and compared it with *T. begonifolia*, although his description was confusing and was the same for several *Tilia* species. In Flora Iranica, Browicz (1981) identified one species in Iran named *Tilia platyphyllos* Scop. with the two subspecies, subsp. *platyphyllos* and subsp. *caucasica* Rupr. It was based on Loria's in 1967 in Caucasasia and seems to apply the same results to the genus *Tilia* in Iran. In another study in 1981, he claimed that the only Iranian *Tilia* is *Tilia caucasica* Rupr. (Browicz & Zielinski, 1982). Many differences between populations and the ecological requirements of species revealed the presence of many taxonomic differences. The result of this study showed that *Tilia platyphyllos* Scop. does not occur in Iran, since the lack of an important characteristic i.e. lack of arista at the end of teeth on margin of leaves. In addition, there is permanent simple hair on the leaves beneath and on the petioles of the *Tilia* yet such characteristics are not found in Iranian *Tilia* specimens. Geographical distribution of *Tilia platyphyllos* revealed that it belongs to Europe and the taxonomical study of the genus *Tilia* in Iran described the differences of *Tilia*

*platyphyllos* with Iranian *Tilia* trees. In this study *T. begonifolia*, *T. rubra* subsp. *caucasica*, *T. dasystyla* and *T. cordata* are introduced as new records for the flora of Iran and *Tilia stellato-pilosa* and *Tilia sabetii* are described and introduced to the science from Iran. The differences and variations on the presence of various species in north forests of Iran are shown in the recent study.

The research carried out in Hyrcanian forests by Yusefzadeh et al., (2010b), considered some morphological characteristics of leaves and trichome on the leaf and petiole as important discriminating traits. The results confirmed the presence of seven groups of leaves with distinguishable characteristics of *Tilia* in Hyrcanian forests yet the presence of *Tilia platyphyllos* was improbable (see Yusefzadeh et al., 2010a, 2010b and 2012).

Yusefzadeh et al., (2012) introduced a new taxon as *T. hyrcana* Tabari & Colagar with presence of disperse stellate trichome on the lower and upper surface and on the petiole, without any comparison with *T. rubra* as the relative species. Study on the same specimens and comparing them with the specimens collected from the field, especially from Kandavan valley, showed that *T. hyrcana* belongs to *T. dasystyla* and can be considered as a variation of it having sparse stellate trichome on the vegetative organs and with or without hairy stigma. These are obvious characteristics of the *T. dasystyla* that Pigot and Francis (1999) have been previously mentioned in their research.

*Tilia stellato-pilosa* and *Tilia sabetii* are rare and endemic species to Dodangeh and Chaloos valley (Mazandaran province), respectively. Geographical distribution of the species reveals the need of conservation measures. Special geomorphology and microclimatic conditions of the areas make them very interesting for the study of botanical and plant species diversity. According to Takhtajan, East Asia is the richest region with 17 species of *Tilia* (Tang & Zhung, 1996), Hyrcanian area may be considered as the second one in the world. In this report, Hyrcanian forests constitute the center of diversity for this genus with six species and one hybrid (*Tilia x euchlora* C. Koch).

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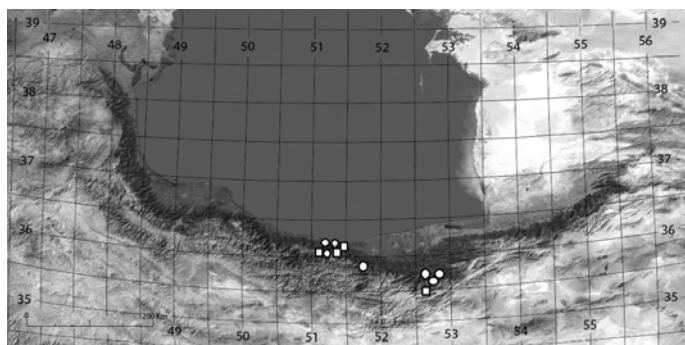


Fig. 8. Distribution map of *Tilia cordata* ○ and *T. dasystyla* □.

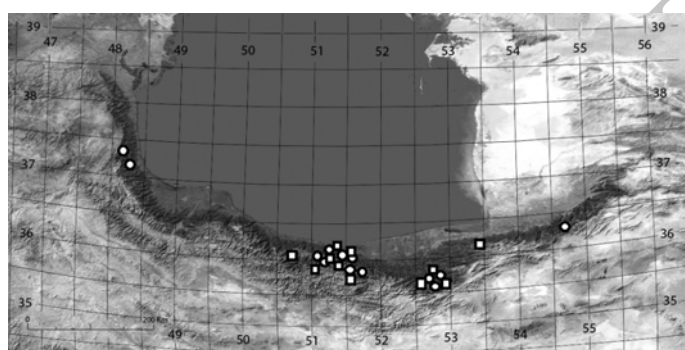


Fig. 9. Distribution map of *Tilia rubra* subsp. *caucasica* ○ and *T. begonifolia* □.

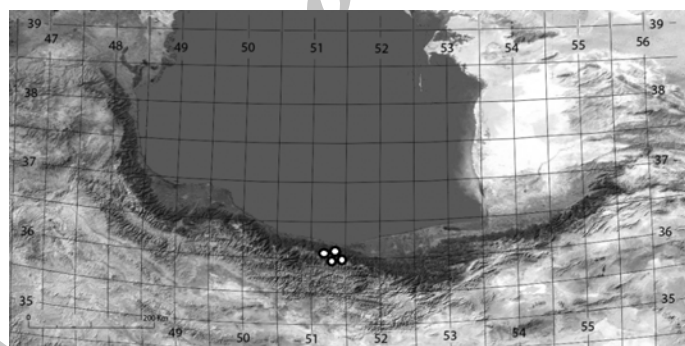


Fig. 10. Distribution map of *Tilia sabetii*.

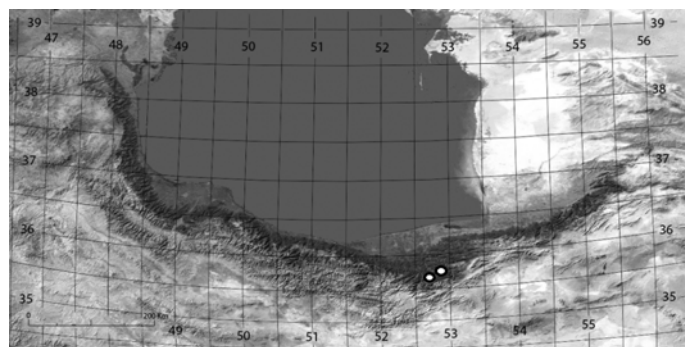


Fig. 11. Distribution map of *Tilia stellato-pilosa*.

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