



## Origin and Classification of the Honey Bee (*Apis mellifera*)

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### أصل وتصنيف نحل العسل الغربي (*Apis mellifera*)

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#### Abstract

The purpose of this study was to investigate the origin and classification of the honey bee (*Apis mellifera*), attempt to catalog its subspecies, and identify their scientific names, as there is considerable confusion and conflicting opinions on this matter. The classification of the honey bee (*Apis mellifera*) faces numerous challenges due to the unique population structure, biological characteristics, and the varying accuracy of methods used to distinguish between the subspecies. Additionally, transitional zones exist between subspecies, resulting in gradual changes in characteristics among neighboring types. It is believed that bees descended from wasps belonging to the family Sphecidae. Bees are thought to have first appeared in tropical regions during the Eocene epoch, about 40 million years ago, and subsequently spread from those regions to Western Asia, North Africa, and Europe. Bees are classified into ten or eleven families, comprising approximately 700 genera and about 20,000 species. The honey bee belongs to the family Apidae and the genus *Apis*, which is its only genus and includes five species:

- The dwarf bee (*Apis florea*)
- The giant bee (*Apis dorsata*)
- The eastern (Indian) bee (*Apis indica* = *Apis cerana*)
- The western (honey) bee (*Apis mellifera*)

Some specialists add a fifth species similar to the giant bee, which is *Apis laboriosa*. Except for the western honey bee, the other species live in the wild and have not been domesticated by humans. The western honey bee (*Apis mellifera*) adapted to primitive hives in ancient times and later to modern hives. As a result of its natural spread and human-mediated transportation to various geographic regions and environments, it acquired traits and characteristics suited to those areas, leading to the emergence of several subspecies (geographic races), with some sources listing more than twenty subspecies or geographic races. These subspecies or geographic races have been classified according to their geographic distribution into four groups and according to color into three groups. There are differing opinions regarding the origin of the honey bee, the number, distribution, and naming of its subspecies, and whether a geographic race is equivalent to a subspecies or represents a lower rank. It should be noted that some do not adhere to the rules of scientific nomenclature and the principles of animal classification.

**Keywords:** Western Honey Bee (*Apis mellifera*), Taxonomy, Subspecies, Geographic Races, Geographic Distribution, Bee Families, Genus *Apis*, Bee Evolution.

#### المخلص

يواجه تصنيف نحل العسل (*Apis mellifera*) تحديات عديدة بسبب التركيب السكاني الفريد، والخصائص البيولوجية، وتفاوت دقة الطرق المستخدمة للتمييز بين النواع. إضافة إلى ذلك، توجد مناطق انتقالية بين النواع، مما يؤدي إلى تغيرات تدريجية في الخصائص بين الأنواع المتجاورة. هدفت هذه الدراسة إلى استقصاء أصل وتصنيف

نحل العسل (*Apis mellifera*)، ومحاولة فهرسة نواعياته Subspecies، ومعرفة أسمائها العلمية، نظرًا لوجود قدر كبير من اللبس والآراء المتضاربة حول هذا الموضوع. يصنف النحل إلى عشر أو إحدى عشرة فصيلة، تضم حوالي 700 جنس وحوالي 20,000 نوع. ينتمي نحل العسل إلى فصيلة (Apidae) جنس (*Apis*)، وهو جنسه الوحيد الذي يضم خمسة أنواع: النحل القزم (*Apis (flore)*)، والنحل العملاق (*Apis dorsata*)، والنحل الشرقي (الهندي) (*Apis cerana*) = (*Apis indica*)، ونحل العسل الغربي (*Apis mellifera*) ويضيف بعض المختصين نوعًا خامسًا مشابهًا للنحل الكبير، وهو نحل العسل العملاق (*Apis laboriosa*). باستثناء نحل العسل الغربي، تعيش الأنواع الأخرى في البرية ولم يستأنسها الإنسان. تكيف نحل العسل الغربي (*Apis mellifera*) مع خلايا النحل البدائية في العصور القديمة، ثم مع خلايا النحل الحديثة. ونتيجة لانتشاره الطبيعي ونقله بواسطة الإنسان إلى مناطق وبيئات جغرافية متنوعة، اكتسب سمات وخصائص ملائمة لتلك المناطق، مما أدى إلى ظهور العديد من النواعيات Subspecies (السلالات الجغرافية)، حيث تُشير بعض المصادر إلى وجود أكثر من عشرين نوعًا فرعيًا أو سلالة جغرافية. وتوصلت نتائج هذه الدراسة إلى تصنيف هذه الأنواع الفرعية أو السلالات الجغرافية وفقًا لتوزيعها الجغرافي إلى أربع مجموعات، ووفقًا لونها إلى ثلاث مجموعات.

**الكلمات المفتاحية:** نحل العسل الغربي *Apis mellifera*، التصنيف، النواعيات، السلالات الجغرافية، التوزيع الجغرافي، فصائل النحل، جنس *Apis*، تطور النحل.

## Introduction

The honey bee has occupied a unique place among entomologists and is favored over other social insects due to its paramount economic importance. As a result, it has received the greatest share of diverse and specialized studies, delving into the most intricate anatomical and biological details. This attention has led scientists, breeders, and enthusiasts to develop their own distinctive approaches and terminology. However, the origin, evolutionary history, number, distribution, and naming of its subspecies remain shrouded in mystery to this day, despite some progress made by taxonomists and evolutionary biologists.

There are many challenges in the classification of the honey bee (*Apis mellifera*), arising from the unique population structure, biological characteristics, and the varying accuracy of methods used to distinguish between its subspecies. Numerous transitional zones exist between the ranges of these subspecies, resulting in gradual variations in characteristics among neighboring types (Ilyasov et al., 2020).

In general, bees comprise twenty thousand or more species, divided into two main groups: the short-tongued bees, which are considered primitive, and the long-tongued bees, which are more advanced. The honey bee (*Apis mellifera*) is one of the long-tongued group. Bees that live solitary or social lives belong to the family Apidae, which includes four species within the genus *Apis*: the dwarf bee (*Apis florea*), the giant bee (*Apis dorsata*), the eastern (Indian) bee (*Apis indica* = *Apis cerana*), and the western (honey) bee (*Apis mellifera*). Some specialists add a fifth species similar to the giant bee, which is *Apis laboriosa* (Mark, 1987; Graham, 2003).

Currently, the honey bee known to taxonomists and breeders falls under *Apis mellifera*, represented as subspecies or geographic races. Among these, three are recognized as standard races: the Italian bee, the Carniolan bee, and the Caucasian bee. These are considered model races, widely used for honey production, and are imported by countries that do not naturally possess them, depending on the climate suitable for each preferred race. In Libya, the Italian bee is imported and raised in the northwest, while the Carniolan bee is raised in the northeast, with both showing clear success in their respective regions. Despite the significant advantages of these standard races, they are not without minor drawbacks.

The remaining races or subspecies are considered non-standard, and there is no consensus among specialists at the local or regional level regarding their distribution and prevalence. Globally, there is also disagreement concerning their naming and classification.

## The Origin of Bees

The origin of bees was in the west of the continent of Gondwana (that is, in Africa and South America), and it is likely that bees originated during the Early Cretaceous period, shortly before the breakup of western Gondwana. The early stages of the evolution of any major bee lineage were associated either with South America or Africa. After that, bees colonized the northern continents through a complex history of continental separation and migration (Hernández et al. 2023).

It is believed that bees descended from wasps belonging to the family Sphecidae and evolved after the appearance of flowering plants, supporting the hypothesis that bees originated from wasps that stopped predation and began collecting nectar and pollen to feed their young. It appears that bees in general appeared in the Tertiary period in tropical regions, and the oldest bee fossils were found in samples of Baltic amber, which date back to the Eocene epoch, about 45 million years ago. Bees spread from those regions to Western Asia, North Africa, and Europe, and were able to adapt and live in extremely cold regions such as the Arctic, for example (Engel et al., 2001). Shaibi et al. (2009) indicated that the groups taken from Libya from the studied samples may be derived from the desert honey bee group, *Apis mellifera sahariensis*, which previously extended during the Holocene rainfall period.

### **Division and classification of bees:**

Bees are divided into 10 or 11 families, comprising about 700 genera and 20,000 species. The honey bee belongs to the order Hymenoptera, family Apidae, and the genus *Apis*, which is its only genus and includes five species: the giant bee, the dwarf bee, the eastern (Indian) bee, the western (honey) bee, and some specialists have added a fifth species, the rock bee (Mark, 1987; Graham, 2003). These four species were classified according to the size of individuals, the method and architecture of hive construction, and the length of the forewing as follows:

The dwarf bee (*Apis florea*): It is considered one of the smallest known bee species in size and the most capable of tolerating high temperatures, which sometimes reach 50°C. It builds a single, small wax comb the size of a human hand on the branches of low shrubs and trees close to the ground. The size of the comb is 15×15 cm, and this species collects small amounts of honey.

The dwarf bee (*Apis florea*) is renowned for its medicinal benefits in the regions where it is found and lives, namely India, Malaysia, Thailand, and Indonesia. It is characterized by extreme docility, so it rarely attacks humans; it cannot insert its stinger into the skin, and the amount of venom injected is small. It is prone to emigration and swarming. Emigration is a method used by this type of bee when the dry season arrives and the pasture no longer meets its nutritional needs, so the members of the colony leave their place for a new location where their needs are met. This migration is called hunger emigration. As for swarming, it occurs when the hive becomes crowded and the number of individuals increases, so the workers build new queen cells to obtain new virgin queens. After the first queen cell hatches (the queens are killed by the new queen or the mother queen), the mother queen migrates with a number of workers of different ages to form a new independent colony. This is the natural method of swarming in bees, and by it, they increase the number of their colonies. The dwarf bee stores honey at the top of the comb, with worker brood in the middle, followed by drone brood, and then queen cells at the lower edge of the comb.

### **The giant bee (*Apis dorsata*):**

This species is considered one of the largest and most aggressive types of bees. It is highly migratory and not domesticated. It builds a single large comb, with dimensions ranging from 60 cm in length and 36 cm in width, and a thickness of 10 cm at the top and 1 cm at the bottom. The honey yield can reach 30–40 kilograms. This comb is suspended on high rock ledges and horizontal tree branches. The tongue of this species reaches 7 mm, which helps it collect nectar from flowers with deep corollas. Honey is stored in the upper part of the comb, and the brood occupies the lower part. Workers are raised in hexagonal cells equal in cross-sectional size to those in the combs of the western bee, but with a depth twice that of the hexagonal cell of the western bee. Therefore, the length of the giant bee worker is double that of the western bee worker. The drones of the giant bee do not differ in size from the workers, as they are raised in hexagonal cells similar to those in which the workers are raised. The giant bee is found in South Asia in India, Malaysia, Ceylon, China, and Indonesia. Although this species is not domesticated, its honey production constitutes 60–70% in India (Mark, 1987; Graham, 2003).

### **The eastern (Indian) bee (*Apis indica* = *Apis cerana*):**

The eastern bee occupies a middle position in terms of individual size, being between the giant bee and the dwarf bee. It inhabits tree cavities and crevices and builds several parallel wax combs, the size of which varies according to the colony and the space it occupies. The eastern bee is highly prone to swarming, and laying workers appear in the colony immediately after the queen is lost. Its swarming differs from that known in domesticated hives and common today, as during the mating flight, the queen is accompanied by a number of workers as well as drones. After mating, the workers stay with the queen and form a swarm that later becomes a new colony. The range of this bee species includes India and Ceylon.

### **The Western (Honey) Bee *Apis mellifera***

The word *mellifera* means "honey-bearing bee," and it is also called *mellifeca*, meaning "honey-making bee." The first name is more common despite being less precise. This species, as is well known, ranks first commercially in honey production, showing significant superiority over the eastern bee in terms of stability in its hives, which it does not abandon.

The previous species, except for the western bee, are limited to India and its neighboring regions. These species live wild in forests and mountains and have not been domesticated by humans. In contrast, the western bee builds its hives in rock cavities, trees, and other places. It is adaptable to being housed in man-made hives. It adapted to primitive hives in ancient times and later to modern hives. As a result of its natural spread and human-mediated transport to different geographic regions and environments, it acquired traits and characteristics suited to those areas and environments. This led to the emergence of several subspecies (geographic races), which some sources list as more than twenty subspecies or geographic races. These are the subspecies relied upon for honey production in most countries worldwide; it is likely that none of these subspecies are completely pure (Morse and Flottum, 1970).

These subspecies or geographic races are classified according to geographic distribution or color. According to geographic distribution, Rothenbuhler (1968) divided them into four groups:

- African subspecies,
- Central Mediterranean and Southeast European subspecies,
- Near Eastern subspecies,
- Western Mediterranean and Northwest European subspecies.

This classification was supported with some modifications by Ruttner (1986, 1988), who proposed 24 subspecies grouped into four clusters as follows:

**A. African Group:** including the subspecies:

1. East African bee *Apis mellifera scutellata* Lepeletier.
2. West African bee *Apis mellifera adansonii* Latreille.
3. *Apis mellifera litorea* Smith.
4. Mountain bee *Apis mellifera monticola* Smith.
5. Egyptian bee *Apis mellifera lamarckii*.
6. Cape bee *Apis mellifera capensis* Escholtz.
7. *Apis mellifera unicolor* Latreille.
8. Yemeni bee *Apis mellifera yemenitica* Ruttner.

**B. Central Mediterranean and Southeast European Group:** including the subspecies:

1. *Apis mellifera sicula* Montagano.

[The list continues beyond this point.]

- **Italian bee:** *Apis mellifera ligustica*
- **Carniolan (Austrian) bee:** *Apis mellifera carnica* Pollmann
- **Macedonian bee:** *Apis mellifera macedonica* Ruttner
- *Apis mellifera cecropia* Kiesenwetter.

**C. Near Eastern Group:** includes the subspecies:

1. **Anatolian (Turkish) bee:** *Apis mellifera anatolica* Maa
2. *Apis mellifera adami* Ruttner
3. **Cypriot bee:** *Apis mellifera cypria* Pollmann
4. **Syrian bee:** *Apis mellifera syriaca* Buttler-Reepen
5. **Caucasian bee:** *Apis mellifera caucasica* Gorbachev
6. *Apis mellifera meda* Sorikov
7. **Armenian bee:** *Apis mellifera armeniaca* Sorikov.

**D. Western Mediterranean and Northwest European Group:** includes the subspecies:

1. **Desert bee:** *Apis mellifera sahariensis* Baldensperger
2. **North African bee:** *Apis mellifera intermissa* Buttler-Reepen
3. **Iberian bee:** *Apis mellifera iberica* Goetze
4. **Dark German bee:** *Apis mellifera mellifera* Linnaeus.
- 5.

Butler (1977) clarified that the original homeland of bees is South Asia, and he divided the western bee into only two subspecies: *Apis mellifera adansonii* and *Apis mellifera mellifera*, while the rest of the western bees are races under these two subspecies.

Mark (1987) attributed the origin of bees to tropical Africa and divided them into three groups according to continents, comprising 21 subspecies as follows: the European group, the African group, and the Asian group. Under each group are geographic races or subspecies.

**A. The European Group:** includes the subspecies:

1. **Dark German bee:** *Apis mellifera mellifera*
2. **Italian bee:** *Apis mellifera ligustica*
3. **Carniolan (Austrian) bee:** *Apis mellifera carnica*
4. **Caucasian bee:** *Apis mellifera caucasica*

There may be other European races that have not been fully studied or have been merged with other European groups. For example, there is the Macedonian bee (*Apis mellifera cecropia*), which seems to belong to the Carniolan group, as well as the Russian bee (*Apis mellifera acervorum*) and the Transcaucasian bee (*Apis mellifera remipes*), which is considered unclear (Mark, 1987).

**B. The African Group:** includes the subspecies:

1. **North African bee (Tellian):** *Apis mellifera intermissa* v. Buttel-Reepen
2. **Egyptian bee:** *Apis mellifera lamarckii*
3. **East African bee:** *Apis mellifera scutellata* Lepeletier
4. **West African bee:** *Apis mellifera adansonii* Latreille
5. **Mountain bee:** *Apis mellifera monticola* Smith
6. **Cape bee:** *Apis mellifera capensis* Escholtz.
- 7.

**C. The Asian Group:** includes subspecies ranging from Turkey in the west to Iran, including:

1. **Anatolian (Turkish) bee:** *Apis mellifera anatolia*
2. **Syrian bee:** *Apis mellifera syriaca*
3. *Apis mellifera meda*

According to color, Abdelsalam (1990), Ibrahim et al. (1998), and Al-Qudairi (1998) divided them into three groups: black bees, yellow bees, and gray bees, with each group containing several races, reaching ten or more.

#### **A. Black bees:**

They are found in Northwest Europe, the Scandinavian Peninsula, and North Africa. The following subspecies fall under this group:

1. **North African bee:** *Apis mellifera intermissa*
2. **German bee:** *Apis mellifera lehzeni*
3. **Yemeni bee:** *Apis mellifera yemenian*

It is noted that there is overlap between the races in terms of color. For example, the authors did not precisely define the geographic location of the black bee, as mentioned in "Fundamentals of Beekeeping and Honey Production" by Al-Qudairi (1998), "Beekeeping and Silkworm Rearing" by Ibrahim et al. (1998), and "Beekeeping and Apiary Management in Egypt and the Arab Countries" by Abdelsalam (1990). Al-Banbi (1993) also added to this group the Swiss bee, the English bee, the Dutch bee, and the French bee.

#### **B. Yellow bees:**

This group is widespread in the Mediterranean region and includes the following subspecies (geographic races):

1. **Egyptian bee:** *Apis mellifera lamarckii*
2. **Italian bee:** *Apis mellifera ligustica*
3. **Cypriot bee:** *Apis mellifera cypria*
4. **Syrian bee:** *Apis mellifera syriaca*
5. **Turkish (Anatolian) bee:** *Apis mellifera anatolica*.

#### **C. Dark (Gray) bees:**

These are found in southeastern Europe and the Caspian Sea region and include:

1. **Carniolan (Austrian) bee:** *Apis mellifera carnica*
2. **Caucasian bee:** *Apis mellifera caucasica*

It appears that the color of the Italian and Egyptian races does not match, even though both are classified under the yellow bee group; the Egyptian bee is dark brown to black, while the Italian bee is golden yellow. Thus, linking color to geographic region is not precise, especially in standard bee races.

The scattered morphometric similarities of local Libyan honeybees with the European *A. m. ligustica* suggest that the importation of honey bees from Italy (by Libyan beekeepers) may have had only a slight effect on the native Libyan honey bee populations. Conservation measures may be particularly suitable for oasis populations, which may be true remnants from the Holocene era (Shaibi et al., 2009).

In a 2019 study by Dar, the number of *Apis* species and identification methods were discussed. According to various authors, the number of species in this genus ranges from 6 to 24. While *Apis mellifera* lives in Western Asia, Africa, and Europe, all other species, including *Apis cerana*, are restricted to Asia. *A. mellifera* and *A. cerana* are the two species most widely used in agriculture for pollination and honey and other product production. Both species have adapted to diverse climatic conditions. The subspecific classifications for these two species remain incomplete and contradictory. All available studies on *A. mellifera* and *A. cerana* were analyzed to organize the modern classification of honey bees. It was found that there are 27 subspecies of *A. mellifera* and 7 subspecies of *A. cerana*. However, these data are not final, as some subspecies of *A. mellifera* and *A. cerana* have not yet been explored (Dar, 2019).

As for the modern taxonomic picture of *Apis mellifera*, according to the study by Ilyasov et al., 2020, thirty-three (33) distinct subspecies were identified, distributed as follows: Africa: 11 subspecies, Western Asia and the Middle East: 9 subspecies, Europe: 13 subspecies. All these subspecies are divided into five major evolutionary lineages.

## Results and Discussion

The most important findings reached through the opinions of specialists in the origin and classification of bees indicate that there are different opinions regarding the origin of the honey bee, the number, distribution, and naming of its subspecies, and whether the geographic race is equivalent to the subspecies or represents a lower rank. There is also disagreement about the very meaning of the term "geographic race." These results also revealed differing views on the distribution of the North African subspecies *Apis mellifera intermissa*; some believe it is present throughout North Africa, including Libya, while others restrict its presence to Tunisia, Algeria, and Morocco.

This study supports the view of Shaibi et al. (2009) that Libyan bees are geographically situated between *A. m. lamarckii* in Egypt to the east and *A. m. intermissa* and *A. m. sahariensis* in North Africa to the west, making Libya a missing link in this west-to-east geographic transition.

In discussing the opinions of bee specialists, it should be noted that the term "race" is used to mean a geographic or ecological race, i.e., a subspecies. According to the rules and principles of animal classification, a race is only recognized if it is geographic or ecological, and thus it is synonymous with subspecies; no ranks lower than that are recognized. Therefore, Butler's (1977) proposal is considered a violation of these rules, and his opinion is somewhat inaccurate. Dietz's (1991) justification that the term "race" in bee hybridization means natural selection (as opposed to races in other animals, which result from human-directed selection) is also not accurate, since human intervention is not limited to artificial insemination—simply moving or importing bees from one place to another and placing them together constitutes non-natural intervention and facilitates interbreeding, which is no different from artificial insemination.

Regarding bee classification, this study agrees with Ilyasov et al. (2020) that there are many challenges in classifying the honey bee (*Apis mellifera*) due to the unique population structure, biological characteristics, and the varying accuracy of the methods used to distinguish between subspecies.

On the issue of subspecies identification, this study concurs with Mark (1987) that distinguishing legitimate subspecies is extremely difficult, mainly due to changes in the natural distribution of subspecies caused by the global movement of bees, and differences among taxonomists and breeders in the use of characteristics. It is emphasized that all characteristics—morphometric, anatomical, behavioral, etc.—should be used to identify subspecies, not just morphometric traits, which are often inaccurate. The variation within subspecies themselves also makes it difficult to draw a clear dividing line to define a subspecies.

From the above, it is clear that even with differing opinions, they should not deviate from the taxonomic principles and rules defined by the classification code, so that a realistic and reliable classification can be achieved.

As for the North African subspecies *Apis mellifera intermissa*, based on my observations as a beekeeper and researcher and my communication with beekeepers in Libya, I have not found evidence of this subspecies in Libya according to the description in Mark (1987) and Dietz (1977). The local bees in northwest and northeast Libya differ entirely from that description. Bees in northwest Libya may be hybrids between local and Italian bees, while those in the northeast may be hybrids between local and Carniolan bees. I do not agree with Al-Banbi (1993) that North Africa is limited to Tunisia, Algeria, and Morocco, but I do agree with him that *Apis mellifera intermissa* does not exist in Libya if that is what he meant. He also did not mention cave and forest bees in Libya, whether they still exist and whether they remain pure as a geographic race. I leave this to a future in-depth taxonomic study to determine whether the local bee can be classified and named as two subspecies or geographic races.

## Conclusion

This study concluded that the origin and classification of the western honey bee (*Apis mellifera*) remain among the most problematic topics in entomology, despite the significant progress made by taxonomists and evolutionary biologists. Researchers' opinions have clearly diverged regarding the geographic origin of the honey bee; some attributed it to South Asia, while other studies confirmed that it originated in western Gondwana (Africa and South America) during the Early Cretaceous period, subsequently spreading to the northern continents.

The results also revealed considerable disagreement regarding the number of subspecies (geographic races), their scientific names, and their geographic distribution, as the numbers cited in the scientific literature ranged from 2 to 33 subspecies, reflecting the extent of confusion surrounding this field. These discrepancies were found to be attributable to several key factors, most notably: the challenges associated with the unique population structure of honey bees, the existence of transitional zones between subspecies leading to gradual variations in traits, the varying accuracy of methods used to distinguish between subspecies, in addition to the over-reliance on morphometric characteristics alone without incorporating behavioral and genetic traits.

With respect to subspecies, the study showed that classification based on color or geographic distribution is not without weaknesses, as overlapping color traits were observed among different groups. Furthermore, human-mediated transport of bees across different regions has led to interbreeding among races and threatens the purity of native subspecies.

In the context of North African subspecies, specifically *Apis mellifera intermissa*, the study concluded that there is insufficient evidence to confirm the presence of this subspecies in Libya according to the descriptions provided

in scientific references. This opens the door for future, more in-depth taxonomic studies that employ integrated approaches combining morphometric measurements, genetic analyses, and behavioral characteristics to accurately determine the taxonomic identity of local honey bees in Libya and to ascertain whether they can be classified as distinct subspecies or represent transitional zones between neighboring subspecies.

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### Compliance with ethical standards

#### *Disclosure of conflict of interest*

The author(s) declare that they have no conflict of interest.

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