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17. BEE VENOM: GLANDS, INTOXICATION, ACCIDENTS

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Primitive bees and wasps are solitary animals. Infra social or social behaviour is a relatively recent evolutionary step paralleled by morphological and physiological adaptative changes.

Our purpose in this study is to discuss some of the changes in the sting apparatus as well as to comment on the bee venom and its action.

Bees are **HYMENOPTERA** from the super family APOIDEA. Michener (1) proposed an evolutionary taxonomic tree for this super family (Fig. 1).

The majority of the families systematized are composed of solitary or infra social bees. In the family APIDAE there are three social tribes: BOMBINI, APINI and MELIPONINI. BOMBINI are the "bumblebees"; among the APINI are the honey-bees and the MELIPONINI are stingless bees.

The sting apparatus of BOMBINI and APINI was studied by Dufour (2) and Bordas (3). It is located in the posterior part of the abdomen between the rectum and the ovaries. Rectum, ovaries and the sting apparatus share a common opening. Two glands were described: one spindle shaped, was called "basic", by Dufour. The other, called "acid", is bifid in its distal part, and thread shaped; the two distal segments unite in a common, long, convoluted, thread like tubule, that opens in a pear shaped reservoir, leading through its proximal, slender segment, in the sting chamber (Fig. 2). In *Bombus* (*Fervidobombus*) *atratus* Franklin, the acid gland is more ramified and the common tubule, before opening in the reservoir, is very short.

MELIPONINI cannot sting, but still have a vestigial sting provided with a glandular sac, the size of which, changes from very large, occupying 2/3 of the abdominal cavity in some species, to very small, vestigial structures, in others (4).

The loss of the sting may be interpreted as a useful evolutionary step, since its sheding, as it occurs in the *Apis* genera, after the action of stinging, is followed by death of the insect. The inability to sting preserves the insect and maintains the colony.

Stingless bees are not defenseless bees: many defense mechanisms have been described (5, 6) as the development of powerful mandibles; the ability to hinder flying or walking performances of the enemies through mixtures of wax and vegetable gums that are sticked to their bodies or moving apendices; the emission of bad smelling or bad tasting secretions; massive attack to repel an intruder, and many others.

The appearance of these defense mechanisms lead to the obsolescence of the sting and its eventual atrophy (4).

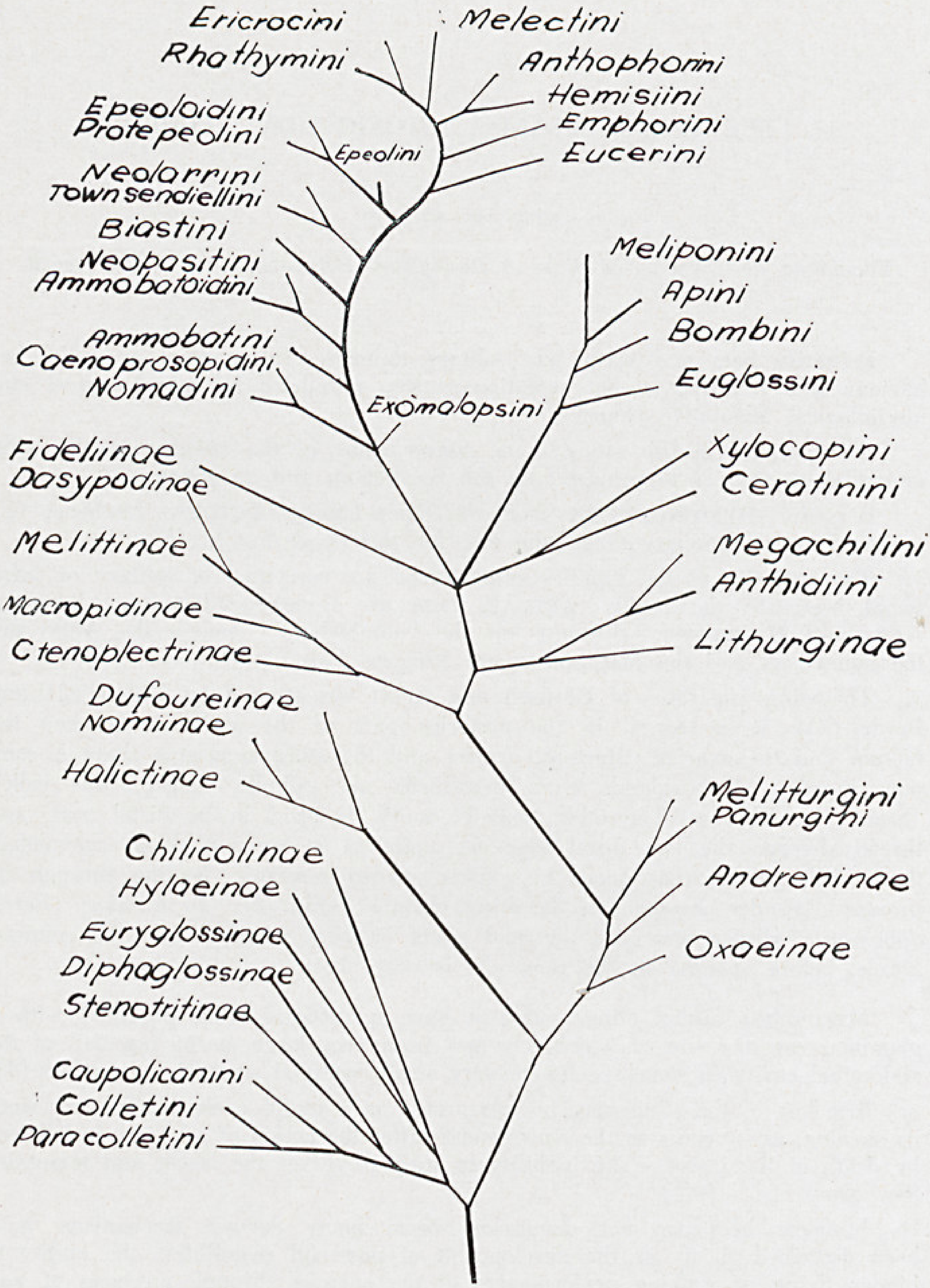

Fig. 1 — Taxonomic tree of APOIDEA according to Michener, 1944.

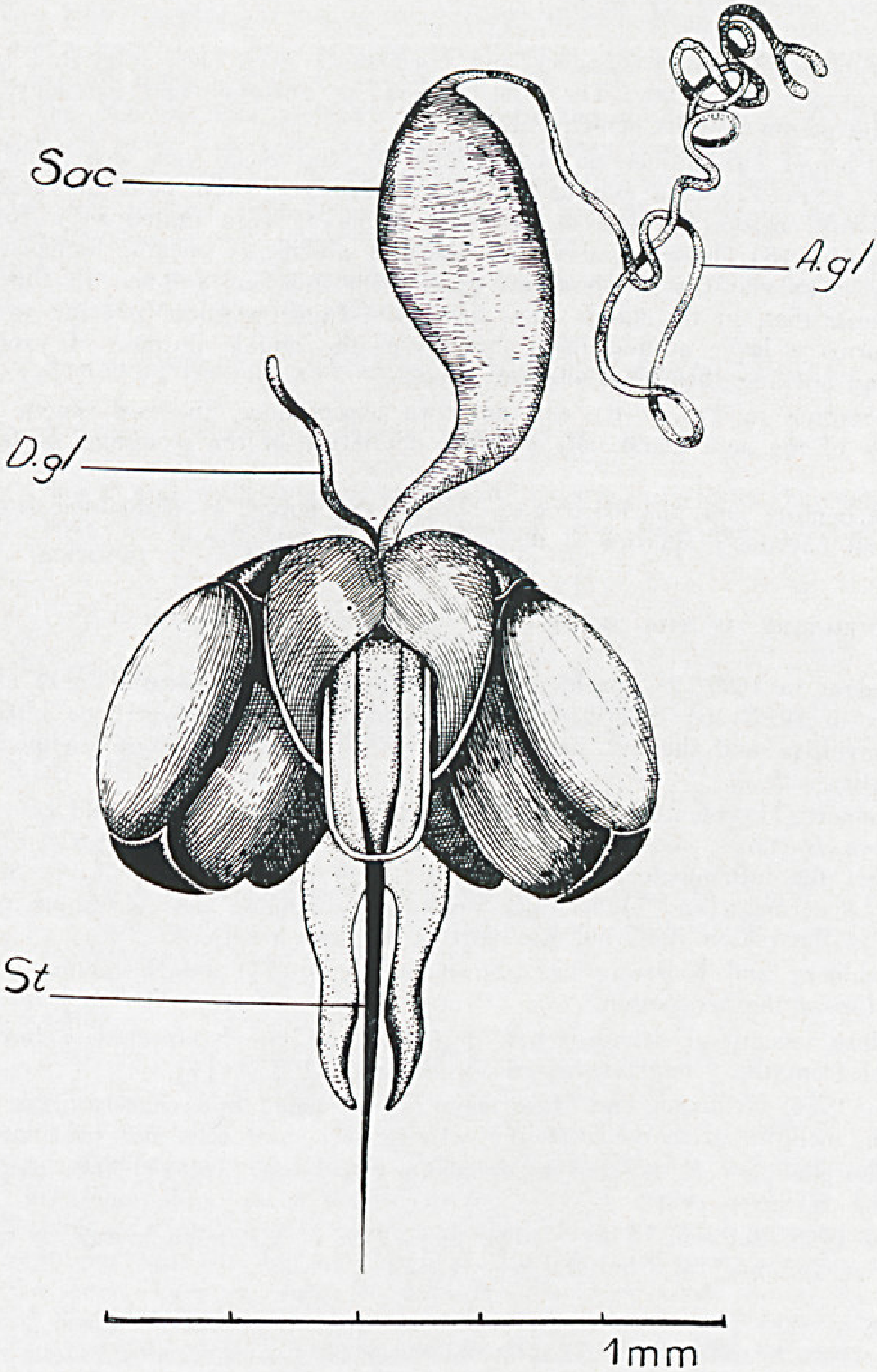

Fig. 2 — Sting accessories of *Apis mellifera adansonii*. A.gl. = Acid gland; Sac = pear shaped reservoir; D.gl. = Dufour gland or "basic" gland; St = sting.

The sting apparatus of Apini

Morphologists, pharmacologists and biochemists have been interested in the sting apparatus of Apini. The first studied its anatomy and histology. The latter, the poison and its consequences.

We began our studies on morphology (4) and could not agree with Dufour (2), Carlet (7) and Bordas (3). They described that, both the acid and basic glands, before opening in the sting chamber, were united in a common duct. Trojan (8), however, described the two glands as opening independently into the chamber. Our observations agree with this last author. In this work he suggests that, in the queen bees, the basic gland secretion, pouring over the eggs, forms a layer around them that serves the double purpose of protecting them and sticking them into the cell walls.

According to Trojan (8) and our own observations, the bee venom is the secretion of the acid gland only and not a mixture of the secretions of the two glands.

Biochemists and pharmacologists studied the poison as eliminated from the sting and not the properties of the secretions of each gland.

The chemistry of the venom

Langer in 1897 (9) considered the bee poison as an essential basic alcaloid. Phisalix in 1922 (10) described three components of the poison; one histiotoxic, one convulsive and the last paralising, each with different physicochemical characteristics.

Reinert (11) identified a protein, rich in triptophane, that could be dialysed into two fractions, one with hemolytic activity, the other neurotoxic. He also said that the inflammatory exudate of the sting contained 1 to 1,5% of histamine. Ackermann and Mauer (12) were of the opinion that histamine was not found in the poison itself but was part of the host reactions.

Feldberg and Kellaway had shown previously (13) the histamine releasing properties of the bee poison.

More recently a dehydrogenase inhibitor and one hyaluronidase have been isolated from the venom (reviewed by Hodgson, 1955) (14).

In 1954, Neumann and Habermann (15) isolated and characterized a basic protein, mellitin, of marked cytolitic activity over mast cells and red blood cells.

Phospholipase A, isolated by Högberg and Uvnäs (16, 17) acts also degranulating rat mast cells.

In 1965, Rothschild (18) studied the release of histamine in rats by phospholipase A and mellitin from the bee venom.

The symptoms and consequences of bee sting

Symptoms and signs of bee sting are very well known by the lay men all over the world. In temperate and cold climates, bee stinging is much more frequent than most of the other poisonous bites or stings by snakes, spiders or scorpions. Despite this, the medical literature on the subject is scarse.

Symptoms may vary from case to case; they usually are more severe when the patient receives numerous stings; they also tend to be more severe after many expositions of the same patient to the poison.

The first symptom is acute, local pain, described as "burning", followed after a few minutes by local swelling and itching; the area shows a small, clear, round, central zone, surrounded by a red halo.

In the case of *Apis mellifera* (honeybee) the sting itself is found in the clear, central zone; it pierces the epidermis and may penetrate 2 to 3 mm in it. Wasps and the majority of the solitary bees, however, do not lose the sting.

The local reaction subsides in a few hours and all the symptoms and signs have usually disappeared after 24 hours.

In a few instances, the consequences are more severe and Thompson (19) ranked them in the following order:

1. Abnormal swelling and irritation, lasting an abnormal time.

2. Massive urticaria and oedema supervening.

3. Shock and collapse or even loss of consciousness with hypotonia and tachycardia, followed by mild pyrexia and sometimes diarrhoea and polyuria.

4. True dyspnoea soon after sting.

5. Sudden severe general symptoms:

   a) hot flush over the whole body;
   b) severe dyspnoea;
   c) wheezing and coughing, almost choking;
   d) general trembling;
   e) great anxiety, sometimes followed by coma. In women this may be accompanied by uterine contractions. This severe condition may last up to three or four days.

6. Death.

Death due to bee sting

The available data about death following bee stinging are not relyable. Swinny (20) reported on seven deaths, in the state of Texas, in 1949; he suggested that this is a conservative estimation, the actual, correct figure being close to 20 to 30 per year in the area studied. Parrish (21) reviewing the mortality due to insect bites or stings in 1950-1954 in the U.S.A. found 84 cases (review of death certificates); from these, 50% were caused by *Apis mellifera ligustica*; at the same time only 71 deaths were ascribed to snake bites.

In Denmarck between 1951 and 1959 bees were responsable for 2/3 of all the deaths ascribed to poisonous animals (22).

All the cited authors were of the opinion that their figures are conservative. Doctors, in general, are very cautious to ascribe death to such a simple and common accident as a bee sting: they rather look for some other more usual cause, as acute cardiovascular disease. Indeed, many authors think that one can better estimate the frequency of deaths after bee sting by reviewing the newspapers than by reviewing death certificates.

Jensen (22) studied 34 cases of deaths due to bee stinging. Fig. 3 and 4 summarize, graphically, his findings. Fig. 3 shows his 22 cases of males and 12 cases of females, by age. Death is rare up to 30 years and the majority of the cases died between 30 and 50 years.

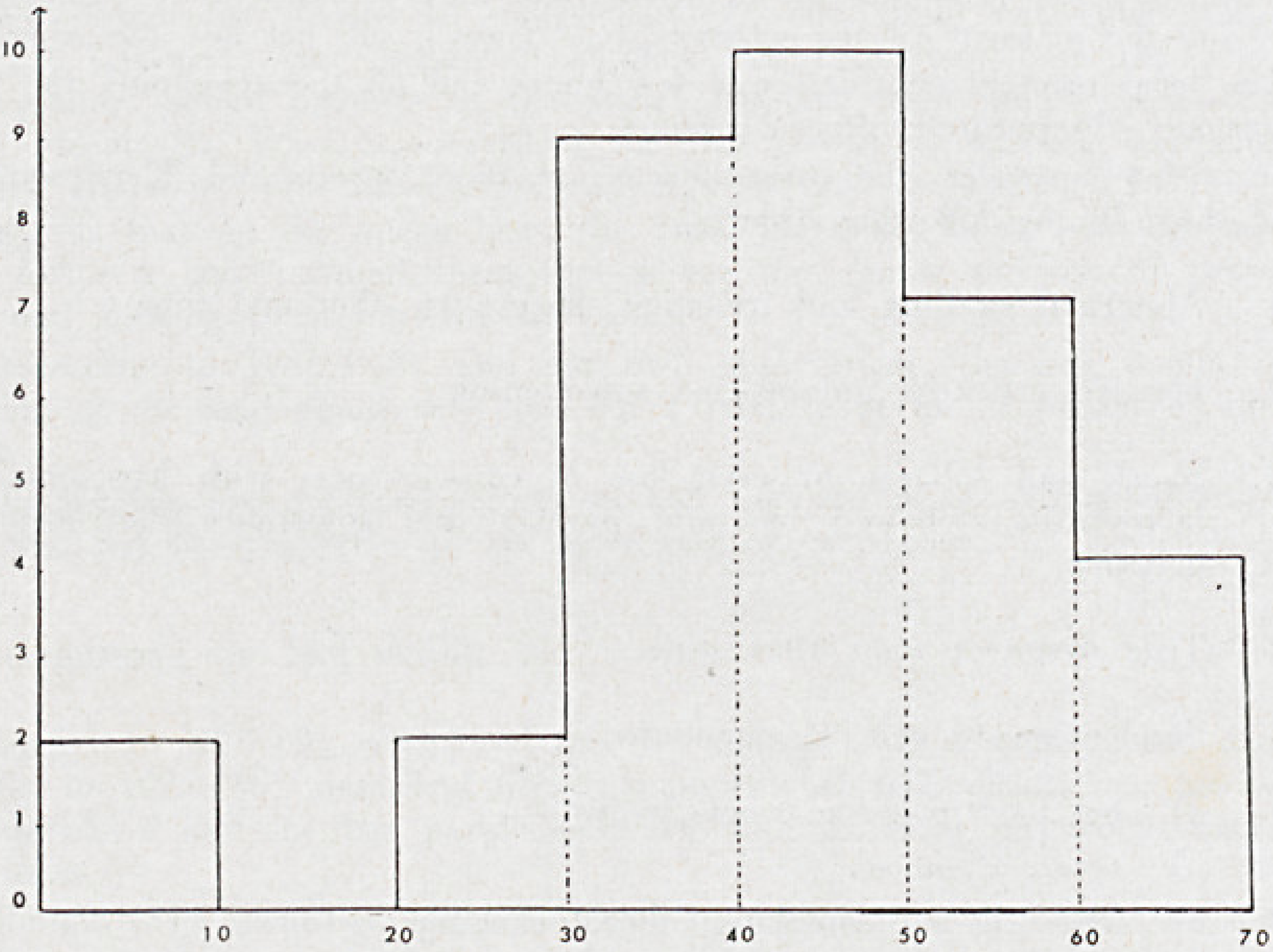

Fig. 3 — Death caused by bee and wasp sting in the U.S.A. according to the age. Data from Jensen, 1961.

Delpech (23) came to the conclusion, that death by bee sting is much more common in adults. From the 34 cases of Parrish (21) only 4 (11,7%) were under 30 years of age; all but five of the cases in his series were perfectly healthy before the accident. The age distribution seems peculiar since children are usually more exposed to bees.

Fig. 4 shows a correlation between death by bee stinging and previous allergic complaints in Jensen cases. In 16 of his 34 cases there was past history of allergic disorders, five had been previously stinged and one had never been stinged before.

The hypothesis that anaphylaxis might be the pathogenetic mechanism of death is atractive. Indeed, death supervenes within one hour of the accident in the great majority of the reported cases. The symptoms are also compatible with the hypothesis being of the same type observed on other types of human anaphylactic shock.

The age distribution of the cases also agrees with the suggested hypothesis. As said above, children are much more exposed to bees than adults; being smaller they should be more susceptible to the poison if one thinks in term of dosage by kg of weight.

Death by other poisonous animals as snakes, spiders or scorpions is more common below 20 years of age (40% between 0 and 19 years). Only 7% of the deaths ascribed to bee sting occur below 20 years of age. In the case of

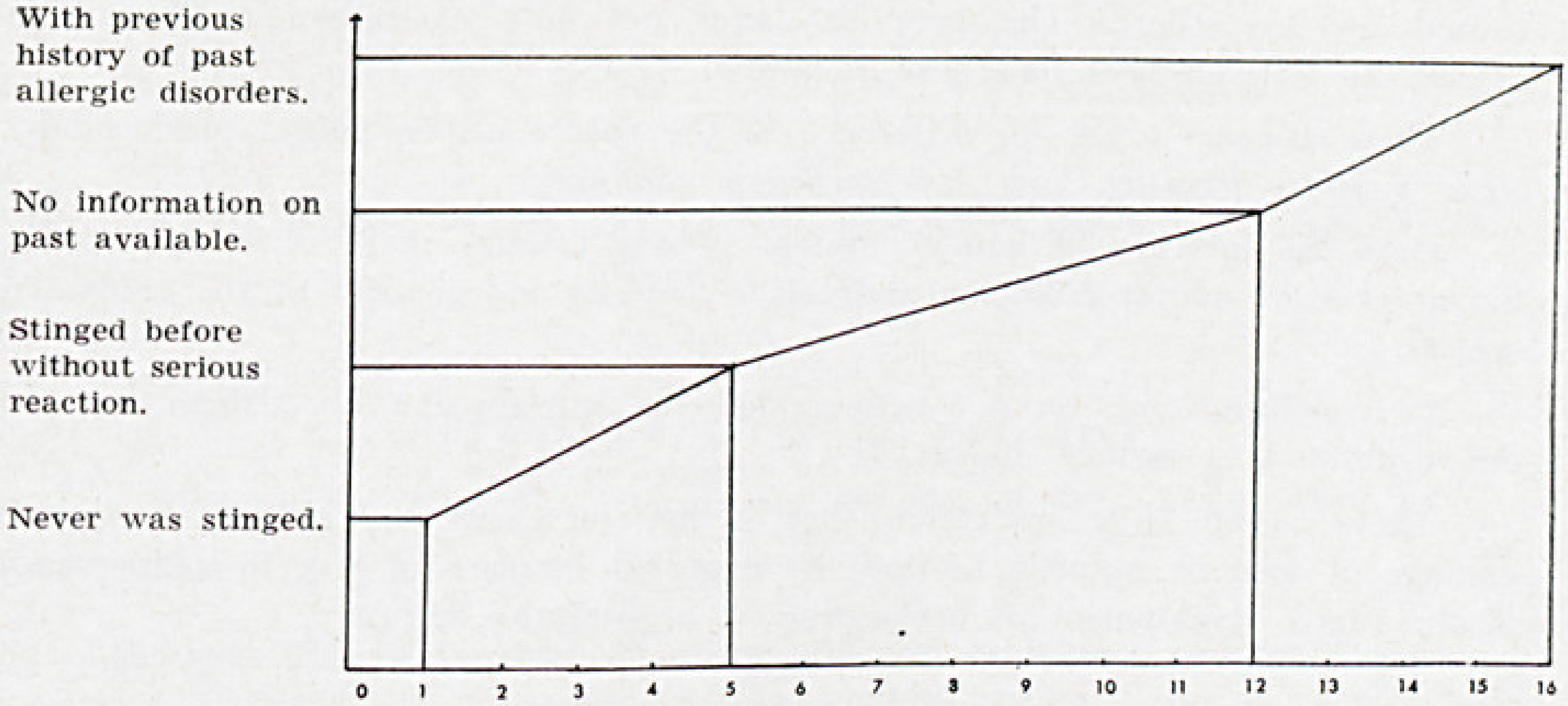

Fig. 4 — Past history of allergy and mortality by bee sting. Data from Jensen, 1961.

snakes, scorpions and spiders there is a definite correlation between dosage per kg of body weight and the severity of the symptoms. We know of 4 beekeepers who have been exposed, in the same day, to 600 to 1500 bee stings who survived, nicely, after the usual local signs and symptoms.

Death by bee sting in Brazil

Up to 1956 our beehives were populated by *Apis mellifera ligustica*, the Italian honeybee. At that time Dr. W. E. Kerr, a geneticist from the "Escola Superior de Agricultura Luiz de Queiroz" in São Paulo, made a trip to Africa sponsored by the State Department of Agriculture, the University of São Paulo and the Brazilian Association of Beekeepers. His objective was to study the possibility of amelioration of the honey yield of our beehives through imbreeding of our Italian honeybees with the more productive *Apis mellifera adansonii*, an African bee. The "African" bee produces about 400% more honey then the "Italian" bee.

Since last year, newspapers in São Paulo have called the attention to an apparent increase in death due to bee stings and the proposed explanation was the agressivity of the "African" bees. At this moment we are collecting data on the subject and our impression is that the facts are not as serious as to advocate the destruction of all African colonies, an action that has been proposed and discussed.

It is true that the African bees are more agressive but the data that we have up to now gathered, register cases of death among chicken and swines. Actual danger to men seems to be exagerated in the press.

In the State of São Paulo, with 16 million inhabitants there were 6 certain human deaths between 1964 and 1965. Two of those cases were men over 70 years of age and one was a small child that was abandoned by his sister at the door of a beehive.

In the same period of one year, in the State of Texas, U.S.A., with a population, at that time, of 8 million inhabitants there were 7 definite deaths caused by bee stings. The bees in Texas are only of Italian or Caucasian origin: no African bees had been imported.

There appears to be no difference in the nature of the poison produced by *Apis mellifera ligustica* and *Apis mellifera adansonii.*

Once the industry of honey develops in any country there is an increase in the number of mortal accidents and this is entirely independent of the cultivated species.

In conclusion, we do not believe that the introduction of African bees in our country is a serious danger.

There is no clear indication that it has increased the risk of a serious damage of men or animals beyond the expected increase of risk in consequence of the rapid development of beekeeping as a profitable industry.

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