bones are clean, so that I can examine them, I shall offer a few more observations upon the osteology of this remarkable animal, for the complete skeleton of which the Canterbury Museum is indebted to the members of the Philosophical Institute, without whose pecuniary assistance I should have been unable to secure it for the Provincial collections.—*Proc. Phil. Institute of Canterbury, New Zealand,* May 5, 1869.

On the Heat evolved by Invertebrate Animals, especially Insects. By MAURICE GIRARD.

M. Girard's memoir commences with a very interesting historical account of the numerous investigations that have been made upon this subject, in which he dwells especially upon the researches of Newport, the most remarkable that we at present possess. On the other hand, he is severe upon Dutrochet, to whom he thinks M. Gavaret has ascribed too much importance; and he brings to light the investigations of Dubost (1800), which have been unnoticed notwithstanding the scientific precision with which they were conducted.

M. Girard's own researches have been made by means of very various processes. He has employed the mercurial thermometer, the little bulb of which he has succeeded in introducing into the rectum of caterpillars and other insects without injury to the animal. He has also made use of the differential thermometer of Leslie, in which he made a modification necessary for his experiments. One of the bulbs presents a deep interior cavity, so that the volume of air contained in the concentric zone is equal to that of the volume of air in the other bulb. The contracted orifice is closed by a cork furnished with a tube, through which air enters and escapes freely. The insect to be experimented on is introduced into this cavity with the precautions necessary to avoid the falsification of the result. M. Girard has also employed thermo-electric needles formed of iron and copper, or, still better, of iron and platinum, such as have already, in the hands of M. Becquerel, done good service in the study of animal heat. Lastly, M. Girard has used the thermo-electric piles of bismuth and antimony, which, since their invention by Melloni and Nobili, have undoubtedly excelled all other calorimetric methods by their exquisite sensibility.

Without going into the details of M. Girard's experiments or indicating the minute precautions taken by him to render their results certain, we may indicate some of his most novel conclusions.

Adult insects, even when sleeping or very weak, never present a diminution of the temperature of the surface of their body below the surrounding temperature. The larvæ and pupæ of insects with an imperfect metamorphosis behave, in this respect, like the adults. Like them, they always present an elevation of temperature above that of the surrounding air, or at least a temperature equal to that of the latter. This is not always the case in insects with a complete metamorphosis. The author has frequently ascertained in caterpillars with smooth bodies that the surface descends below the temperature of the surrounding air, which shows that the evolution of heat by the respiratory combustion may be insufficient to compensate for the loss due to superficial evaporation or cutaneous transpiration. The same fact occurs in chrysalids. The cocoon with which the pupæ of a great number of Lepidoptera and Hymenoptera envelope themselves serves to prevent a too rapid desiccation of the animal, which would superinduce a fatal superficial refrigeration. In fact, pupæ present a distinct elevation of temperature at the moment when they are taken out of the cocoon; then, in the air, they lose their weight by evaporation, and the surface of their body often descends below the temperature of the surrounding air. In winter, naked torpid caterpillars and pupæ return to the surrounding temperature or to a very slight excess above it. The superficial refrigerations due to evaporation are not produced when the temperature very nearly approaches 32° F., a result perfectly conformable with the results of physical researches.

Sex exerts a marked influence on the evolution of superficial heat in certain groups of insects. Thus in the Bombycidæ the males are warmer than the females. Something of the same kind seems to occur among the Phryganidæ and Pieridæ. But we must be careful in generalizing these results.

The experiments of M. Girard upon the differences of temperature according to the regions of the body are undoubtedly very curious. In caterpillars the heat is not localized in a few segments, but belongs to all, which agrees well with the analogous dissemination of the nervous centres. This is by no means the case in insects with powerful aërial locomotion. The variation of temperature shown by them between the thorax and the abdomen may become very considerable. In the Humble Bees, and especially in the Sphingidæ, whose flight is so powerful, the excess of the thoracic over the abdominal temperature amounts commonly to from 7° to 11° F., or even sometimes to from 14° to 18° F. We may say that in insects endowed with aërial locomotion the heat is concentrated in the thorax into a focus of intensity proportional to the effective power of flight. These results are in conformity with anatomical data. In the thorax there are the strong muscles both of the legs and wings. The latter, being in energetic contraction during flight, are the seat of an active combustion; on the contrary, the muscles of the abdomen are then inert. We must not be surprised that the equalization of temperature does not take place so rapidly as in the vertebrata. If we consider a wasp (a *Polistes* or a *Sphex*), the abdomen of which is united to the thorax only by a slender peduncle, how slowly must the currents of the blood be transmitted between these two regions through so narrow a strait! We may see how the heat developed in the thorax during the movement of flight must pass with difficulty into the abdomen, even if it ever reaches this part.

Another fact, intimately connected with that just referred to, is as follows. M. Girard has ascertained that, in the Humble Bees and *Xylocopæ*, the external evolution of heat is in relation to the buzzing. The temperature falls as soon as the insect ceases to buzz, but rises again as soon as the buzzing is resumed; and this takes place many times successively.—*Annales des Sciences Naturelles*, tome xi. (1869) p. 134; *Bibl. Univ.* January 15, 1870, *Bull. Sci.* p. 83.