Aristotle on How Animals Move: The De incessu animalium*: Text, Translation, and Interpretative Essays*, edited by Andrea Falcon and Stasinos Stavrianeas, Cambridge: Cambridge University Press, 2021. Pp. xv + 315.

Aristotle's *De incessu animalium* (*IA*) or *On the Progression of Animals* is a short treatise on the 'parts that are useful to animals for motion with respect to place' (704a4-5; translation from Falcon & Stavrianeas). Unlike related texts, such as *On the Motion of Animals* (*MA*) or *Parts of Animals* (*PA*), *IA* has received undeservedly little attention. This volume, edited by Andrea Falcon and Stasinos Stavrianeas, is therefore a very valuable addition to the study of Aristotle's biology. Crucially, it contains a new critical edition of *IA* by Pantelis Golitsis, alongside a collaborative translation. Moreover, the nine essays, together with Falcon's introduction, provide the first recent comprehensive account of the nineteen chapters of *IA*. The present volume, then, will be the starting point for future research into the treatise and should be of great interest to any reader of Aristotle's biological works.

My review will be in three parts: First, I will say more about the structure and content of *IA*, especially the principles of natural investigation on which the treatise relies. Second, I will discuss the contributors' stances towards the most famous of those principles, namely that 'nature does nothing in vain' (704b15; 708a9-10). Finally, I will turn to specific issues concerning the locomotion of animals, as treated in some of the essays in the collection.

1. *De incessu animalium*

At the beginning of *MA*, Aristotle says with reference to *IA*: 'Concerning the movement of animals, those features which apply to each kind of them—what their differences are, and for

what reasons they each have their particular features—have all been investigated elsewhere' (698a1-4, tr. Morison in Rapp & Primavesi 2020). By contrast, in *MA*, he will investigate 'quite generally, the common cause of this moving, whatever type of movement it is' (698a4-5). Thus, both *IA* and *MA* contribute to the study of animal motion, but *IA* gives a specific account of various animal kinds, from humans to crabs. On the other hand, *IA* differs from *MA* in that the latter belongs to the study of what is common to body and soul, as pursued in the *Parva naturalia*, whereas soul is not discussed in *IA*. In this respect, then, *IA* is more closely tied to strictly 'biological' works, such as *PA* and *Generation of Animals* (*GA*). In particular, *GA* I.3-16 and *IA* complete the account of animal parts from *PA* II-IV by investigating, respectively, the generative and locomotive parts of animals.

IA itself is organized around eleven questions, stated in *IA* 1 (704a9-b7). These questions seek explanations of facts that are 'clear from natural research (ἐκ τῆς ἱστορίας τῆς φυσικῆς)' (704b10). Some concern the number of 'points' (σημεῖα) by which animals move, that is, the points of contact between an animal and the medium in which it moves (e.g., feet or fins). For instance, the first question is, 'what the fewest points by means of which animals move are' (704a10), and the third question asks, 'in general, why some animals are footless, some two-footed, some four-footed, and some many-footed' (704a12-13). Other questions deal with issues concerning the motion of limbs, especially the bending of legs. For example, the seventh question is, 'why a human being and a bird, although they are both two-footed, have opposite bendings of their legs' (704a17-18). The eleven questions from *IA* 1 do not exhaust the agenda of *IA* (Falcon, pp. 105-9). For instance, Aristotle raises additional questions in *IA* 14-15 about the motion of eyes in crabs and the oblique attachment of wings and fins (Jansen, p. 267). Still, *IA* 1 reflects the central topics of the treatise.

Aristotle's eleven questions are addressed in *IA* 7-19, while *IA* 2-6 mostly lays the ground for that later discussion. The core preparatory work is done in *IA* 2, where Aristotle states

three principles crucial for 'natural investigation' (704b13): First, 'nature does nothing in vain' (704b15-18). Second, there are six 'dimensions (διαστάσεις) of magnitude' in three pairs, namely, up and down, front and back, and right and left (704b18-22). Third, the *per se* 'sources' (ἀρχαί) of locomotion are pushing and pulling (704b22-5a2). *IA* 3 builds on these principles (705a3) to argue in affinity with *MA* 2 that anything that moves requires at least two parts: one that compresses and one that is compressed (705a19-21).

In *IA* 4, Aristotle expands on the second principle and clarifies that the distinction between the six dimensions 'is one of function, and not merely of position relative to earth and the heavens' (705a29-30). That is, the dimensions should be understood with reference to the functions of organisms. For instance, 'that from which food and growth is distributed is the up' (705a32-33), and hence, 'roots are the up for plants' (705b6). Similarly, 'the part in which sense-perception is naturally implanted and from which each animal derives it is the front, whereas the opposite parts are the back' (705b12-13), and 'the origin of movement is from the right' (705b30; cf. 705b18-20). As Dimas argues, this account can be reconciled with the 'positional' account of dimensions from *De caelo,* which ascribes dimensions to the universe itself, if we recognize that, for Aristotle, the universe, too, is alive (Dimas, p. 128).

We will see that the second principle matters for Aristotle's account of the locomotive parts of animals. But first, let us look at the famous first principle that nature does nothing in vain.

2. Nature principles

In full, the first principle in *IA* 2 reads: 'nature does nothing in vain but always <does> what is best from among the possibilities for the substance of each kind of animal, which is why if it is best in a certain way, it is also in this way according to nature' (704b15-18). Let us call it

the ‘vanity principle’. Aristotle’s explanation of the footlessness of snakes in *IA* 8 illustrates the principle (restated at 708a9-12): Snakes are blooded animals, and hence cannot move with more than four points (708a17-18). Also, they are disproportionately long compared to ‘the nature of the rest of their bodies’ (708a15-16). Thus, if they had two or four feet, as blooded animals with feet do, ‘they would be almost completely motionless’ (708a18-19). Therefore, snakes, and long blooded animals in general, cannot have feet (708a14-17).

One question about the vanity principle is whether it breaks into two principles, as Lennox has argued: a *negative* principle that nature does nothing in vain, and a *positive* principle that nature does what is best among the possibilities for each animal kind (Lennox 2001, p. 215). Some authors follow Lennox in this regard (Stavrianeas, p. 181; Jansen, p. 268), but others insist that it is a single principle, the second half of which explicates the first: For nature to do nothing in vain is for it to realize the best possibility for an animal kind (Falcon, p. 110; Rangos, p. 236; cf. Henry 2013, p. 230). Since at least Stavrianeas thinks that the principles work in conjunction (Stavrianeas, pp. 180-82), not too much may hinge on the disagreement. But it is worth noting that, in *IA* 8, Aristotle includes the full two-part formulation in the scope of a single article (τό … εἶναι, 708a9-12) as the cause of the footlessness of snakes. This suggests that, in *IA*, Aristotle does not think of the two parts as independent principles that serve different explanatory purposes.

Another question concerns the reference of ‘nature’. Aristotle emphasizes that nature does ‘what is best from among the possibilities for the substance (οὐσία) of each kind of animal’ (*IA* 2, 704b16-17) and ‘preserves the proper substance and essence of each of them’ (*IA* 8, 708a11-12). On the standard view, ‘nature’ refers not to a cosmic nature analogous to a Platonic demiurge but to the formal nature of a natural kind (Stavrianeas, p. 185; Rangos, p. 237; cf. Lennox 2001, p. 189; Henry 2013; Morel 2016). For example, it is part of the nature of snakes that they are blooded animals, and this (partially) explains why it is best for snakes

to be footless. But Jansen, though she agrees that 'nature' does not refer to a cosmic nature, argues that it may refer to features that cut across natural kinds (Jansen, p. 269). In *IA* 15, for instance, Aristotle says that birds bend their legs towards the concave and their wings towards the convex, just as four-footed animals bend their back legs towards the concave and their front legs towards the convex (712b22-30). According to Jansen, Aristotle here relies on a version of the vanity principle where 'nature' refers to a functional feature (the function of front legs and wings to initiate progression) *not* of a natural kind but of a non-natural grouping that includes both four-footed animals and birds (Jansen, pp. 275-79).

Rangos responds that Aristotle appeals to facts about 'physical reality' that are grounded in the essence of the genus animal (Rangos, pp. 237-38). Hence, the relevant functional features are those of a natural kind (animal). But a less ambitious defence of the standard view seems available too: In comparing the limbs of birds with those of four-footed animals, Aristotle says that 'in a way (τρόπον τινά) their nature is nearly the same (παραπλησίως)' (712b23). This need not commit him to a non-natural grouping of birds and four-footed animals with a "nature" of its own. For he says that the limbs of birds and four-footed animals have a very similar nature, not that their nature is the same. It seems unlikely, then, that Aristotle relies on the vanity principle (which is not stated in *IA* 15) to appeal to a single "nature" or feature shared by members of the non-natural grouping of birds and four-footed animals. Instead, he seems to explain the bending of bird limbs by mere analogy with four-footed animals.

Other claims about nature in *IA* deserve attention, too. In *IA* 11, Aristotle explains why humans, or anything of a similar shape, cannot be winged (711a2-7) on the grounds of the principle that 'nature does nothing contrary to nature (παρὰ φύσιν)' (711a7). As Clarke shows, this second nature principle follows from the vanity principle: If nature realizes the best possibility for a kind, it does not do anything contrary to its nature (Clarke, pp. 231-32). Moreover, the standard reading of the reference of 'nature' can be applied again: Since our

nature is our ability to think, and the ability to think requires an upright posture (*PA* IV.10, 686a27-32), which in turn requires that we walk on two feet (*IA* 11, 710b5-10), it follows from human nature that we walk on two feet (Corcilius, pp. 151-52; Clarke, pp. 226-27). According to Aristotle, then, human nature does not endow us with wings that would impede our ability to walk because doing so would be contrary to human nature (711a5-7).

But not all occurrences of 'nature' in *IA* can be brought in line with the standard view as easily. In several places, Aristotle implies a hierarchy of animal kinds in accordance with their naturalness. For instance, in *IA* 7, he refers to 'animals that are constituted according to nature in the highest degree (τὰ μάλιστα συνεστηκότα κατὰ φύσιν)' and says that they move by two or four points (707b5-7). Similarly, in *IA* 5, he claims that the human being 'is two-footed most of all in accordance with nature (μάλιστα γὰρ κατὰ φύσιν ἐστὶ δίπους)' (706b10, my translation). Moreover, in the final chapters, Aristotle discusses animal kinds that are in some sense unnatural or deformed (as discussed by Witt 2012, albeit without reference to *IA*): 'Crabs are the most oddly constituted in nature (πεφύκασιν) among the many-footed animals' (*IA* 17, 713b11-12), the nature of flatfish is warped (*IA* 18, 714a8), and hard-shelled animals move 'in a way contrary to nature (παρὰ φύσιν)' (*IA* 19, 714b13-14).

These passages seem to rely on a third nature principle that might be expressed as follows: An animal is *natural* to the degree to which it accords with nature. For instance, blooded animals, which usually move with two or four feet, accord most of all, or to the highest degree (μάλιστα), with nature. Hence, blooded animals are more natural than other animals. If Aristotle held some such principle, one can raise further questions as to the reference of 'nature'. For instance, does 'nature' in claims to the effect that animals are more or less 'in accordance with nature (κατὰ φύσιν)' refer to the same entity as in 'nature does nothing in vain'? If one adopts the standard reading of the vanity principle, an affirmative answer faces difficulties. For the claim that an animal is more or less in accordance with nature seems to

require reference to a nature other than the nature of the animal kind in question. After all, every animal kind seems equally in accord with its own nature.

In response, Corcilius draws on *PA* IV.10, 686a27-b2, to argue that the standard against which animal kinds are judged is either divine nature or human nature (Corcilius, pp. 152-53). In particular, the closer the nature of an animal kind is to divine nature, the 'better its nature and its way of life is' (Corcilius, p. 153). This suggests that, for instance, blooded animals are most in accordance with *divine* nature. This interpretation is attractive but constitutes a departure from how the standard reading of the vanity principle construes 'nature'. For the standard reading is designed to avoid reference to anything other than the natures of the relevant animal kinds. By contrast, if we allow that 'nature' can refer to divine nature, we are close to conceding that it may refer to a sort of cosmic nature after all. In turn, if we admit that, in *IA*, 'nature' may refer to a cosmic nature, we might want to reconsider our insistence on excluding any such reference from the vanity principle. At any rate, this volume is a springboard for further exploration of the issue.

3. Locomotion and bending

Besides shedding light on the principles of biological enquiry, *IA* is a trove of arguments about the locomotion of various animals. Many receive their first recent treatment in this volume. Of course, I cannot do justice to all of them. But let me highlight a few topics, as discussed by Corcilius, Frey, and Clarke.

According to Corcilius, *IA* 5-6 develops an 'architecture' of locomotive bodies on which the rest of the treatise relies: The locomotive parts of animals are 'articulated' according to four

dimensions (right and left, up and down) and have one common origin at the centre of the body (Corcilius, p. 141). Corcilius argues that *IA* 6 aims to establish a 'single theorem': that 'there is a common origin of motion in the animal' (Corcilius, p. 156). Philologically, this view relies on an apodotic reading of the particle 'δέ' towards the end of *IA* 6 at 707a8, or alternatively, Golitsis' new reading 'γέ' (Corcilius, p. 163): The relevant δέ (or γέ) clause introduces not a further condition, as others have thought, but draws a conclusion, indeed, *the* conclusion of *IA* 6: the theorem of the common origin of motion (707a8-16).

One might ask advocates of this interpretation of *IA* 6 further questions about the transition to *IA* 7. At the beginning of *IA* 7, Aristotle concludes: 'It is evident, then, that motion with respect to place belongs either only or above all to those animals that make <their own> change with respect to place either by means of two or four points' (707a16-19). On a natural reading, *this* is the main conclusion at which Aristotle aimed in *IA* 6. The translation in the present volume adds 'their own' to stress that animals have a principle of motion and thus to connect the claim with the theorem of the common origin of motion (Stavrianeas, pp. 168-69). However, prima facie, the sentence says simply that locomotion belongs only or above all to animals that move with two or four points. This conclusion does not seem to rest on the theorem of the common origin of motion. Instead, it relies on another claim from *IA* 6: that 'all animals that advance using instrumental parts have them distinguished not by the differentiation of front and back, but rather by that of the remaining two pairs' (706b33-7a3).

Corcilius acknowledges the importance of the latter claim when he lists it as one of two main conclusions of *IA* 6, alongside the theorem of the common origin of motion (Corcilius, p. 164). But one may be tempted to press the issue further: Perhaps the primary goal of *IA* 6 is to establish the fourfold differentiation of locomotive parts. For unlike the theorem of the common origin of motion, the fourfold differentiation of locomotive parts directly bears on the conclusion in *IA* 7: If the locomotive parts of animals are differentiated according to four

dimensions, they move with four points of motion, namely, four feet or two feet plus either two wings or two hands and arms (*IA* 5, 706a28-29). This reading could take on board the compelling apodotic reading of the δέ (or γέ) at 707a8: The clause does draw a conclusion, and this conclusion is the theorem of the common origin of motion. But one might argue that the latter is a further claim that *follows from* the central conclusion of IA 6 rather than itself the central conclusion.

Frey argues that, in *IA* 9, Aristotle introduces an applied mathematical science, namely, 'mathematical kinesiology' (Frey, p. 195). This science emerges from Aristotles geometrical arguments for the claim that walking requires bending (708b26-9a4; 709a14-24). In the first of these arguments, Aristotle argues that, as a walker moves one leg forward, the other leg will be perpendicular to the ground, and the lead leg, if kept straight, will be the hypotenuse of a right-angled triangle (with the two legs and the line between the feet as its sides). Following Frey's reconstruction, by the Pythagorean theorem (709a1-2), if the lead leg is five units long, and one takes a stride of three units, the distance from the hip of the second leg to the ground must be four units. But the legs are equally long (709a2). So, for the distance from the hip to the ground to be four units, the second leg must be bent (Frey, p. 199).

According to Frey, this argument does not merely draw on a geometrical analogy or illustration, as elsewhere in Aristotle, but relies on a geometrical principle (namely, the Pythagorean theorem) as an ineliminable premise (Frey, pp. 202-3). Hence, he concludes that the arguments in *IA* 9 belong to an applied mathematical science (mathematical kinesiology) which is subordinate to geometry but superordinate to observational biology (Frey, pp. 204-7). Mathematical kinesiology, then, has the same status as, for instance, mathematical optics.

But one might wonder whether *IA* 9 is sufficient evidence for ascribing another science to Aristotle. The appeal to geometry begins with Aristotle's claim that the leg that supports the

weight is ‘like a perpendicular line to the ground’ (708b32, my translation). The ‘like’ (οἷον) can be read as introducing an illustration for a heuristic purpose. Moreover, the Pythagorean theorem may not play as prominent a role as Frey claims. Aristotle alludes to it in passing, as he describes the lead leg as a ‘hypotenuse’, and it seems merely intended to characterize the triangle in question as a right triangle (709a1-2). *Pace* Frey, then, it is not clear that Aristotle means to introduce the theorem as a demonstrative premise. Admittedly, the argument does not rest on an observation of how we walk; we rarely stride with a straight lead leg. Still, it seems in the purview of observational biology to show that, even if a walker keeps one leg straight, nonetheless, the *other* leg must be bent, and so bending occurs after all. Geometrical reasoning is helpful to see this, but it is not obvious that a geometrical principle is required to establish that, even in such a case, walking requires bending.

Clarke’s discussion of *IA* 10-11 focusses on the important topic of two-footedness. In famous passages outside of *IA*, Aristotle relies on the definition of the human being as ‘biped animal’ (see, e.g., *Meta*. Z.12, 1037b12; H.6, 1045a15). This definition is a toy definition since two-footedness is not the essence of humans but, as seen above, merely follows from the essence (our ability to think). Still, *IA* 11 is illuminating because it fills in some details of Aristotle’s account of human two-footedness, in contrast with the two-footedness of birds.

In the discussion of humans (710b5–11), Aristotle explains why humans, given that they are upright, are two-footed and why, compared to their upper body, the lower parts of their body are heavier than in other footed animals. The latter explanation is more explicit: To walk upright, humans need strong and heavy legs. Two-footedness itself is not explained at length, but Clarke plausibly fills in the account: Blooded animals, such as humans, cannot have more than four feet, and the number of their feet must be even (*IA* 8). Hence, humans

must have two or four feet. But surely, they could not walk in an upright manner with four feet. Therefore, humans must be two-footed (Clarke, p. 226).

The discussion of the two-footedness of birds (710b17-30) is less straightforward. Aristotle adverts to two physical features of birds to explain why they can be upright: 'their weight is situated at the back' (710b18-19) and they have a large ischium (710b20-30). But, as Clarke points out, while these features explain why birds *can* be upright, they do not explain why they are actually upright. He addresses this worry by emphasizing a participial phrase in the sentence initiating the discussion: 'birds, *being light*, are two-footed because of the fact that their weight is situated at the back' (710b17-19). Clarke suggests that it follows from the nature of birds as flyers that they must be light, and that therefore, it is better for them to have two rather than four legs (Clarke pp. 228-229).

However, in the quoted sentence, Aristotle does not seem to appeal to lightness to explain the two-footedness of birds. For their two-footedness is explained by the weight distribution. Rather, lightness appears intended to set apart the way in which birds are two-footed from the way in which humans are two-footed. We just learned that humans have particularly heavy legs. But birds, although also two-footed, are light. Hence, the two-footedness of birds needs a different account which appeals to their weight distribution and their ischium. But it is not clear that Aristotle means to give a further explanation of the two-footedness of birds in terms of their lightness. (Although another explanation is given in *PA* IV.12, 693b5-15 (see Clarke, p. 229, fn. 44): As blooded animals, birds cannot move with more than four points, and since they have two wings, they cannot have more than two feet.)

IA differs from many other Aristotelian treatises in being largely uncharted territory. As my brief remarks have hopefully indicated, the contributors to this collection greatly advance the

state of debate concerning the intricate arguments of *IA*. More generally, anyone interested in Aristotle's natural science will profit from working through this stimulating volume.*

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References

Henry, D. (2013), 'Optimality Reasoning in Aristotle's Natural Teleology', *Oxford Studies in Ancient Philosophy* 45: 225-63.

Lennox, J. G. (2001), *Aristotle's Philosophy of Biology*, Cambridge University Press.

Morel, P.-M. (2016), '"La nature ne fait rien en vain": Sur la causalité finale dans la *Locomotion des animaux* d'Aristote', *Philosophie antique* 16: 9-30.

Rapp, C., and Primavesi, O. (ed.) (2020), *Aristotle's* De motu animalium: *Proceedings of the XIX. Symposium Aristotelicum*, Oxford University Press.

Witt, C. (2012), 'Aristotle on Deformed Animal Kinds', *Oxford Studies in Ancient Philosophy* 43: 83-106.